STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION 2003 3RD EDITION

August 2003 Version

Table of Contents

Titles and headings of sections contained herein are for convenience of reference and shall not be considered as having any bearing on the interpretation of the specification. The frequencies and methods of sampling and testing materials shall be as required by the City of Omaha Materials Testing Manual unless otherwise modified by the Engineer or Contract Documents. Use the latest published version as of the date of advertisement for bids for any references contained herein.

GENERAL PROVISIONS

1 References and Terms

1.01 Agency References, Abbreviations, and Acronyms 1
1.02 Other References, Abbreviations, and Acronyms 2
1.03 Definition of Terms 3

2 Proposal Requirements and Conditions

2.01 Qualification of Bidders 19
2.02 Proposal Forms 19
2.03 Interpretation of Quantities 20
2.04 Examination of Site of Work and Contract Documents 20
2.05 Preparation of Proposals 21
2.06 Alternates, Ties, and Limitations 21
2.07 Irregular Proposals 21
2.08 Proposal Guaranty 22
2.09 Delivery of Proposals 22
2.10 Withdrawal of Proposals 22
2.11 Public Opening of Proposals 22
2.12 Disqualification of Bidder 23
2.13 Material Guaranty 23

3 Award and Execution of the Contract

3.01 Consideration of Proposals 25
3.02 Award of Contract 25
3.03 Cancellation of Award 25
3.04 Return of Proposal Guaranties 25
3.05 Requirements with Respect to Contract Bond 26
3.06 Execution of Contract 26
3.07 Failure to Execute Contract 26
3.08 Notice to Bidders 26

4 Scope of Work

4.01 Intent of Contract 27
4.02 Alteration of Plans or Character of Work 27
4.03 Extra Work 27
4.04 Maintenance of Detours 28
4.05 Removal and Disposal of Structures and Obstructions 28
4.06 Rights In, and Use of Materials Found on the Project 29
4.07 Final Clean Up 29

5 Control of Work

5.01 Authority of the Engineer 31
5.02 Plans and Working Drawings 31
5.03 Conformity with Plans and Allowable Deviations 31
5.04 Coordination of Contract Documents 32
5.05 Cooperation of the Contractor 32
5.06 Cooperation with Utilities 32
5.07 Cooperation between Contractors 33
5.08 Construction Stakes, Lines, and Grades 34
5.09 Authority and Duty of the Project Representative 34
5.10 Inspection 34
5.11 Removal of Unacceptable Work and Materials 35
5.12 Restrictions on Moving and Use of Heavy Equipment 35
5.13 Use of Adjacent Land Under Contract or Lease 36
5.14 Final Inspection 36

6 Control of Materials

6.01 Material Source and Delivery 37
6.02 Local Material Sources 37
6.03 Samples, Tests, and Cited Standards 37
6.04 Plant Inspection 37
6.05 Facilities for Field Inspection and Testing 37
6.06 Material Delivery, Storage, and Handling 38
6.07 Unacceptable Materials 38
6.08 City Furnished Materials 39
6.09 Excess Material Disposal 39

7 Legal Relations and Public Responsibility

7.01 Laws to be Observed 41
7.02 Permits, Licenses, and Taxes 41
7.03 Patented Devices, Materials, and Processes 41
7.04 Restoration of Surfaces Opened to the Public 41
7.05 Federal and State Participation 42
7.06 Sanitary Provision 42
7.07 Public Convenience and Safety 42
7.08 Barricades, Danger, Warning, and Detour Signs 42
7.09 Preservation and Restoration of Property 42
7.10 Right-of-Way 43
7.11 Responsibility for Damage Claims 43
7.12 Insurance 43
7.13 Opening Sections of the Project 44
7.14 Contractor's Responsibility for Work 44
7.15 Contractor's Responsibility for Utility Property and Services 45
7.16 Personal Liability of Public Officials 45
7.17 No Waiver of Legal Rights 45
7.18 Use of Explosives 45
7.19 Third-Party Beneficiary Clause 46
7.20 Hazardous Material 46

8 Prosecution and Progress

8.01 Subletting or Assigning of the Contract 47
8.02 Determination of Contract Time Allowable for Completion of the Work 47
8.03 Prosecution of the Work 48
8.04 Limitation of Operations 49
8.05 Character of Workers 49

8.06 Contractor Methods and Equipment 49
8.07 Temporary Suspension of the Work 50
8.08 Progress of the Work 50
8.09 Liquidated Damages 50
8.10 Completion of Default Contracts 51
8.11 Guarantee 52
8.12 Termination of the Work 53
8.13 Incentive for Early Completion 53

9 Measurement and Payment
9.01 Measurement of Quantities 55
9.02 Scope of Payment 55
9.03 Compensation for Altered Quantities 55
9.04 Differing Site Conditions, Changes, Extra Work, and Force Account Work 56
9.05 Eliminated Items 58
9.06 Progress Payments 58
9.07 Stored Materials 59
9.08 Acceptance and Final Payment 60

10 Wages and Conditions of Employment
10.01 Scope 61
10.02 Labor Laws 61
10.03 Employment of Labor 61

CONSTRUCTION SPECIFICATIONS

100 Site Preparation
101 Clearing and Grubbing 63
102 Removal of Structures and Obstructions 67
103 Sewer Abandonment 73
104 Pavement Milling/Removal 81
105 Brick Pavement Removal 85
106 Traffic Signal Removal 87
107 Crack and Joint Repair 91

200 Earthwork
201 Excavation and Embankment 99
202 Subgrade Preparation 105
203 Fly Ash Stabilization 109
204 Flowable Fill 111

300 Aggregate Surfaces and Bases
301 Aggregate Subbase/Base Course 113
302 Aggregate Surface Course 117
303 Recycled ACP Surface/Base Course 119
304 Recycled PCC Surface/Base Course 123

400 Flexible Pavements
401 Asphaltic Concrete Pavement 129
402 Asphaltic Concrete Curb 143
403 Pavement Fabric Reinforcement 149
404 Bituminous Surface Treatment 151
405 Fog Seal 155
406 Slurry Seal 157

500 Rigid Pavements
501 PCC Pavement ... 159
502 PCC Curb, Combination Curb and Gutter, and Integral Curb Construction ... 175
503 PCC Sidewalk, Median Surfacing, and Mow Strip ... 189
504 Low Strength Concrete ... 205

600 Structural Construction
601 Concrete Barrier Curb ... 217
602 Sheet Piling ... 229
603 Box Culverts ... 231
604 Guardrail ... 245
605 Segmental Retaining Wall ... 253
606 Reinforced PCC Retaining Wall ... 259
607 Noise Walls ... 271
608 PCC Stairs ... 283
609 Railings ... 295

700 Sewer/Subsurface Construction
701 Sewer Construction ... 299
702 Manholes, Inlets, Appurtenances, and Special Structures ... 321
703 PCC-Lined Channels and Flumes ... 347
704 Water Service Facilities ... 359
705 Video Sewer Inspection ... 365

800 Roadside Improvement and Erosion Control
801 Topsoil ... 367
802 Seeding ... 369
803 Sodding ... 377
804 Plant Materials ... 381
805 Mulch ... 389
806 Rip Rap ... 393
807 PCC Slope Protection ... 395
808 Slope Drains ... 407
809 Rolled Erosion Control ... 409
810 Temporary Erosion and Pollution Controls ... 417
811 Articulated Block Erosion Control ... 423
812 Gabion Baskets and Revet Mattresses ... 427
813 Fence ... 431

900 Traffic
901 Poles, Mast Arms, and Cantilever Structures ... 439
902 Truss Structures ... 457
903 Signals and Luminaires ... 475
904 Traffic Signal Controllers ... 487
905 Electrical Cable and Duct Installation ... 503
906 Pavement Markings ... 517
907 Barricades and Signage ... 527
908 Service Disconnects ... 543
909 Vehicle Detectors ... 553
910 Modular Video Vehicle Detection System ... 559
911 Preemption Control System ... 569
912 Wide Area Video Vehicle Detection System ... 573

1000 Miscellaneous Items
1001 Public Information Services 587
1002 Sprinkler System Relocation/Replacement 589
1003 Mail Boxes 591
1004 Field Offices 593
1005 Brick Pavement 595

Index 599

0000 GENERAL CONDITIONS

1 – REFERENCES AND TERMS

1.01 Agency References, Abbreviations, and Acronyms.

Interpret the following references, abbreviations, and acronyms as follows:

AAN ..... American Association of Nurserymen
AAR ..... Association of American Railroads
AASHTO ..... American Association of State Highway and Transportation Officials
ACI..... American Concrete Association
AGC ..... Association of General Contractors
AIA..... American Institute of Architects
AISC ..... American Institute of Steel
AISI..... American Iron and Steel Institute
ANSI ..... American National Standards Institute
ARA ..... American Railroad Association
AREMA..... American Railway Engineering and Maintenance Association
ARTBA..... American Road and Transportation Builders Association
ASA..... American Standards Institute
ASCE ..... American Society of Civil Engineers
ASLA ..... American Society of Landscape Architects
ASTM ..... American Society for Testing and Materials
AWPA..... American Wood Preservers' Association
AWS..... American Welding Society
AWWA ..... American Water Works Association
CFR..... Code of Federal Regulations
EEI ..... Edison Electric Institute
EPA..... Environmental Protection Agency
FHWA ..... Federal Highway Administration
FR..... Federal Register
FSS..... Federal Specifications and Standards
GSA..... General Services Administration
IEEE ..... Institute of Electrical and Electronic Engineers
IES ..... Illuminating Engineering Society
IMSA ..... International Municipal Signal Association
IPCEA ..... Insulated Power Cable Engineers Association
ISO ..... International Standards Organization
ITE ..... Institute of Transportation Engineers
MIL..... Military Specifications
MUTCD..... Manual on Uniform Traffic Control Devices

NCMA.....National Concrete Masonry Association
NDEQ .....Nebraska Department of Environmental Quality
NDOR .....Nebraska Department of Roads
NEC.....National Electric Code
NEMA.....National Electrical Manufacturer's Association
NESC .....National Electric Safety Code
NFPA .....National Fire Protection Association
NNRD .....Nebraska Natural Resources Department
OSHA.....Occupational Safety and Health Act
REA.....Rural Electrification Administration
RRS .....Reissue Revised Statues of Nebraska
SAE .....Society of Automotive Engineers
SHRP .....Strategic Highway Research Program
UL .....Underwriters Laboratories
US.....United States
USASI .....USA Standards Institute
USC .....United States Code

1.02 Other References, Abbreviations, and Acronyms.

Interpret the following references, abbreviations, and acronyms as follows:

ABS .....Acrylonitrile Butadiene Styrene

AC .....Asphalt Cement – Asphalt specifically refined as to quality and consistency for use in the manufacture of asphalt pavements.

ACC .....Asphaltic Cement Concrete – A pavement material comprised of mineral aggregates coated and cemented together using asphalt cement.

AWG .....American Wire Gauge

BST .....Bituminous Surface Treatment – A relatively thin, bituminous treated wearing surface

CMP .....Corrugated Metal Pipe

CPM .....Critical Path Method – An activity-oriented procedure for detailed project planning and control

CSP .....Corrugated Steel Pipe

HDPE .....High Density Polyethylene – Thermoplastic, high molecular weight, organic compound comprised of many molecules of ethylene.

ID.....Identification

LDPE ..... Low Density polyethylene – Thermoplastic, low molecular weight, organic compound containing ethylene molecules

LRFD ..... Load Resistance Factor Design

LSC ..... Low Strength Concrete

PC..... Portland Cement – A cement, manufactured by combining, burning, and finely grinding a combination of lime, silica, alumina, iron oxide, and other additives, capable of hardening through a chemical reaction with water

PCC..... Portland Cement Concrete – A construction material comprised of mineral aggregates coated and cemented together using portland cement and other additives.

PG Binder..... Performance Graded Binder – Asphalt cement graded in accordance with the test procedures contained in AASHTO MP-1.

psi ..... Pounds per Square Inch

PVC..... Polyvinyl Chloride – Synthetic resin prepared by the polymerization of vinyl chloride

RCP..... Reinforced Concrete Pipe – Concrete pipe containing rods or fibers to withstand greater stresses and strains

VCP..... Vitrified Clay Pipe – Fired clay pipe generally used for sewers

1.03 Definition of Terms.

Define the following terms as follows:

Acceleration Lane..... See Auxiliary Lane.

Access..... Facility providing entry or exit from one area to another.

Act of God ..... Earthquake, lightning strike, tornado, or any other cataclysmic phenomenon of nature beyond the Contractor's control causing loss, damage, or injury to the work.

Addendum..... Written alteration, clarification, or correction of the bidding documents or Contract Documents issued after the Notice to Bidders and before a bid opening.

Admixture ..... Material other than water, aggregates, hydraulic cement, and fiber reinforcement

used as an ingredient of concrete or mortar and added to the batch immediately before or during mixing.

Advertisement ..... Public announcement requesting services or bids for work or furnishing materials.

Affiliate Companies ..... Companies having an individual who is an officer, director, or partner in both companies or having an individual, individuals, or legal entities that own or control a minimum of twenty (20) percent of the stock of both companies.

Alley ..... Established pedestrian and vehicle access between or behind buildings abutting a street.

Approved ..... Favorably confirmed or accepted.

Arterial Street ..... Main road, street, or avenue, primarily for through traffic, with collector roads, streets, or avenues joining it.

Assignment of Contract ..... Written agreement whereby the Contractor sells, assigns, or transfers rights in the contract to an individual or legal entity.

Auxiliary Lane ..... Portion of roadway adjoining the through traveled way for parking for parking, speed changes, or other purposes supplementary to through traffic movement.

Avenue ..... See Street.

Award ..... Acceptance of a proposal.

Award Date ..... Date the City notifies the successful Bidder of the award.

Award Letter ..... Letter notifying the successful Bidder of the award.

Backfill ..... Operation involving the placement of materials in a trench or excavation. Also, material(s) used in such an operation.

Backslope ..... Downward-sloping surface toward a roadbed or other improvement.

Base, Base Course ..... Layer or layers of designed material constructed on a subbase or subgrade to support the surface material.

Bid Date ..... Date indicated in the Contract Documents on or before which the City must receive all proposals.

Bid Opening ..... Act of publicly declaring a portion or all of a Bidder's proposal.

Bid Time ..... Time indicated in the Contract Documents on or before which the City must receive all proposals.

Bidder ..... Individual or legal entity submitting a proposal for advertised work.

Bond ..... A promissory note provided by a Surety.

Borrow Pit ..... Excavation site that provides material for use in another location.

Bridge ..... Structure, including supports, spanning between two elevations above a lower elevation and having a centerline length of more than twenty (20) feet.

Bridge Length ..... Distance measured along the line of survey stationing from end to end of the bridge floor. The bridge length shall not be less than the total clear opening of the structure.

Bridge Roadway Width ..... Distance measured at right angles from the longitudinal bridge centerline to the curb bottoms, guard timbers, or lower risers.

Bridge Substructure ..... Portion of a bridge structure below the bearings of simple and continuous spans, skewbacks or arches, and tops of rigid frame footings, including backwalls, wingwalls, and wing protection railings.

Bridge Superstructure ..... Portion of a bridge structure excluding the bridge substructure.

Calendar Day ..... Every day, beginning and ending at midnight, shown on the calendar, including Sundays and holidays.

Change Order ..... Written order to the Contractor detailing changes to the specified work quantities or modifications in the scope of the original Contract.

Channel ..... A natural or artificial waterway.

City.....City of Omaha. A municipal corporation established under the authority delegated by the Constitution of the State of Nebraska known as the City of Omaha.

City Council .....Elected legislative body of the Mayor-Council form of government as created by the Home Rule Charter of 1956.

Coarse Aggregate.....Mineral aggregate or portion of a mineral aggregate that retains on a #4 (6.4mm) screen.

Collector Street .....Street providing access to abutting property that collects local street traffic and feeds an arterial street.

Commencement of Work .....Date upon which Contractor's operations begin, unless otherwise stated in the Contract Documents, on the items of work covered by the contract either within the right-of-way or outside of the right-of-way but requiring the presence of a Project Representative.

Completion Date .....Specific calendar date by which either on or before the Contractor must complete all work.

Contract.....Binding written agreement between two parties detailing the obligations of each to perform the prescribed work.

Contract Bond.....Approved security executed by the Contractor or its Surety, or sureties, guaranteeing completion of the specified work and payment of all legal debts pertaining to the work.

Contract Documents.....Invitation for Bids, Proposal, Contract, Contract Bond, Specifications, Supplemental Specifications, Special Provisions, Materials Testing Manual, General Conditions, Plans, Detailed Plans, Change Orders, Notice to Proceed, and any agreements required to satisfactorily complete the work, including authorized extensions thereof, all of which constitute one instrument.

Contract Item.....Specific work unit for which the contract provides a price.

Contract Period ..... Period of time from the specified date to commence work to the date that the specified number of working days or calendar days has elapsed, or to the specified completion date as indicated in the contract.

Contract Price ..... Unit or Lump Sum value for furnishing all labor, equipment, and materials for performing the work as described in the plans or specifications.

Contract Sum ..... Total monetary amount for all work contained within the Contract Documents.

Contract Time ..... Date, number of working days, or calendar days allowed to complete the Contract.

Contractor ..... Individual or legal entity contracted to perform the work.

Control of Access (Full) ..... Authority to control access that allows access to select roads only and does not allow connections to driveways and grade crossings.

Control of Access (Partial) ..... Authority to control access that allows some access to select roads and may allow driveways and some grade crossings.

Controlling Operation ..... Operation that, if uncompleted, delays the completion of the work.

County ..... Administrative subdivision of the State used to designate or identify the location of the proposed work.

Cul-de-sac ..... Local street open at only one end with special provision for turning around.

Culvert ..... Structure providing an opening under any roadway excluding bridges, transverse drainage tile, or other intakes designed to aid subsurface drainage.

Days ..... Calendar Days.

Dead-end Street ..... Local street open at only one end without special provision for turning around.

Deceleration Lane ..... See Auxiliary Lane.

Defective Work ..... Work not in compliance with the Contract Documents that the Contractor must correct, rework, or remove and replace.

Deficient Work.....Work not in reasonably close conformance with the contract requirements or otherwise inferior, but, in the opinion of the Engineer, is reasonably acceptable for the intended use and may remain in place.

Delay (Compensable).....Excusable event, action, force, or factor causing work to extend beyond the specified contract time for which the Contractor may be entitled to additional compensation.

Delay (Excusable) .....Contractor's inability to meet a milestone/phase completion date due to circumstances beyond the Contractor's control for which the Engineer may grant a time extension.

Delay (Non-excusable).....Reasonably foreseeable delay to the contract completion date within the Contractor's control and for which there is no monetary compensation or time extension.

Delay (Noncompensable).....Excusable event, action, force, or factor causing work to extend beyond the specified contract time for which the Contractor may be entitled to additional time without additional compensation.

Department .....See Public Works Department.

Department of Roads.....Department of the State of Nebraska authorized by law to improve and maintain the State Road System.

Differing Site Conditions.....Subsurface or latent physical conditions at the site that:

- Differ materially from conditions normally encountered or generally recognized as inherent in the nature of the work required; and
- Differ materially from those indicated in the Contract; and
- Present unknown or unusual physical conditions.

Divided Highway/Street .....Highway/Street with separated roadways for traffic in opposite directions.

Drainage Ditch.....Artificial open depression, excluding a roadway ditch, constructed for surface water movement.

Drawings .....See Plans.

Early Start Date.....Earliest date that the Contractor may commence work.

Embankment.....Area of fill the top of which is higher than the surrounding surface or the original surface.

Employee .....Person receiving compensation from and who is under the direct control of the Contractor or a Subcontractor performing work on a project mentioned by the contract.

Engineer .....City Engineer, or authorized representative of the City Engineer, acting within the scope of the assigned duties or the authority given.

Engineer's Estimate.....Estimate compiled by the Engineer of predicted cost based upon past experience and available information.

Equipment.....Machinery, tools, apparatus, and supplies necessary to preserve, maintain, construct, and satisfactorily complete the contract.

Equitable Adjustment .....Adjustment in the contract price and/or time.

Excavation.....Operation involving the removal of earth or rock.

Excavation Limits.....Vertical and horizontal boundaries established to control the excavation process.

Expressway.....Divided arterial street with full or partial control of access and generally grade separations at intersections.

Extra Work .....Item of work, not provided for in the contract, determined by the Engineer to be essential for the satisfactory completion of the contract within its intended scope and paid in accordance with the extra work order.

Extra Work Order.....Written order, unplanned at the time of bidding, authorizing a Contractor to perform work beyond the scope of the

contract documents that is paid for using a supplemental agreement or as force account work.

Federal Agency .....Federal agency or officer succeeding in accordance with law to the powers, duties, jurisdiction, and authority of the agency or officer.

Final Completion .....Satisfactory completion of all specified work, including punchlist items, and delivery of all required documents, certificates, and proofs of compliance.

Fine Aggregate .....Mineral aggregate or portion of a mineral aggregate that passes through a #4 (6.4mm) screen and retains on a #200 (75µm) sieve.

Force Account Work .....Work paid based on the actual reasonable cost of labor, equipment, materials furnished, overhead, and profit.

Foreman.....Representative of the Contractor in charge of a specific trade, group of workers, or part of the project responsible to the Superintendent.

Foreslope .....Downward-sloping surface away from a roadbed or other improvements.

Foundation Course .....Layer or granular material under portland cement concrete pavement providing frost resistance and a stress-distributing medium.

Freeway .....Expressway with full control of access.

Frontage Road .....Local road auxiliary to, and located on the side of, an arterial street for service to the abutting properties and areas, and for control of access.

Furnished Materials .....Materials provided or made available to the Contractor by the City or other designated source at no cost to the Contractor.

Grade Separation.....A crossing of two streets, or a street and a railroad, at different elevations.

Haul Road.....Traveled way designated for hauling equipment, materials, or machinery.

Highway.....See Street.

Holidays.....January 1, Memorial Day, July 4, Labor Day, Thanksgiving Day, and December 25.

Incidental.....Minor expense or occurrence that accompanies an item of work.

Incidental Work.....Work performed by the Contractor that is not directly paid. The cost for providing the work is included in one or more other contract prices.

Independent Contractor .....See Subcontractor.

Intermediate Contract Time.....Calendar or working days allowed for performing a specific contract item or group of contract items.

Irregular Proposal.....Conditional, incomplete, erroneous, or altered proposal as identified in Subsection 2.07.

Item.....See Contract Item.

Joint Bid .....Proposal submitted by a joint venture of which all parties are collectively responsible for the completion of the work.

Joint Venture .....Joining of two or more individuals or legal entities for the purposes of submitting a single bid on a single proposal.

Late Start Date.....Latest date upon which the Contractor shall commence work.

Legal Axle Load.....Maximum vehicle axle load allowable by law.

Local Street .....Street or road primarily used for access to residences, businesses, or other abutting property.

Lump Sum.....Bid amount for all work necessary to satisfactorily complete a contract item that is not directly measured.

Major Work Item .....Work item that the Contractor must complete in order to occupy or use the project for its intended purpose.

Materials .....Substance specified for use in the satisfactory completion of the work contained in the contract.

Materials Testing Manual.....Manual developed by the City that indicates the testing or inspection guidelines for the work.

Mayor .....Elected executive and administrative power of the City.

Median.....Planted or paved section between two or more lanes in or near the center of the street and not intended for vehicular travel.

Median Lane .....Auxiliary lane adjacent to a median that accommodates left-turning vehicles.

Mineral Aggregate.....A relatively inert, granular material of mineral composition.

Notice to Bidders.....Public announcement requesting services or bids for work or furnishing materials.

Notice to Proceed .....Written notice to the Contractor to begin work including the contract time starting date.

Outer Separation .....Area between an arterial street and a frontage road.

Parking Lane.....Auxiliary lane primarily for vehicle parking.

Parkway.....Arterial street for non-commercial traffic, with full or partial control of access.

Partial Payment .....See Progress Payment.

Pavement Structure.....Pavement layer or layers constructed atop a subgrade supporting and distributing the traffic load to the roadbed.

Paving Lane.....Full width and length of a layer of pavement constructed at a single time.

Payment Bond.....Approved form of security furnished by the Contractor and the Surety as a guaranty that all bills and accounts for materials and labor used in the work will be paid in full.

Performance Bond.....Approved form of security furnished by the Contractor and the Surety as a guaranty that the work will be completed in accordance with the terms of the contract.

Permanent Easement.....Strip of land within a larger area to which the property owner grants permanent

right-of-access by an individual or legal entity.

Permanent Pavement ..... Pavement layers requiring only routine maintenance throughout the design life.

Plans..... Contract drawings or electronic digital images showing the location, character, and dimensions of the prescribed work, including layouts, profiles, cross sections, and details.

Pre-Approved Source..... A source that is deemed acceptable prior to the submittal of any information.

Pre-Cast Concrete ..... Conventionally reinforced (not pre-stressed) concrete products formed, cast, and cured in a casting yard and later incorporated into the work.

Pre-Qualified Contractor..... Contractor the City determines has the skill, ability, and integrity to satisfactorily perform and finance the work contained in the contract before submitting a proposal to do the work.

Pre-Stressed Concrete..... Concrete subjected to compressive stresses, after hardening, using high strength tendons, for the purposes of eliminating or minimizing tensile stresses in the concrete due to applied loads.

Project Representative ..... Authorized representative of the Engineer assigned to observe and document any or all work contained in the contract.

Profile Grade..... Trace of a vertical plane intersecting the top surface of the proposed wearing surface of a road.

Progress Payment ..... Payment issued for completed portions of the work or for materials required for the work that are in inventory and stored on the project or at a designated location to a specific date.

Project ..... Specific work, performed at a specific location, in accordance with a contract.

Proposal..... Written offer to perform the work contained in the contract.

Proposal Form ..... Approved form on which formal bids are prepared and submitted.

Proposal Guaranty .....Security furnished with a proposal guaranteeing the Bidder will enter into the contract upon acceptance of the proposal.

Public Works Department .....City government division directly charged with the responsibility for the design, construction, maintenance, and operation of the public streets, alleys, sewers, and related installations.

Punchlist .....List compiled near the completion of work indicating the work remaining and items the Contractor must furnish to complete the work outlined in the Contract.

Radial Highway .....Arterial street leading to or from an urban center.

Ramp.....Connecting roadway between intersecting streets at a grade-separated intersection.

Reasonably Acceptable.....Acceptance of work not in reasonably close conformance with the contract requirements, or otherwise inferior, that the Engineer determines will remain in place for a discounted price.

Reasonably Close Conformity ..Compliance with working tolerances or, in the opinion of the Engineer, reasonable and customary manufacturing and construction tolerances where working tolerances are not specified.

Rejected Proposal .....Proposal rendered invalid by the City.

Responsive Bid .....Bid meeting all requirements in the notice to Bidders.

Resources.....Labor, equipment, and materials necessary to perform the work contained in a contract bid item or other element of work.

Right-of-way.....Land, property, or interest acquired for or devoted to drainage, sewer, or transportation purposes.

Road.....See Street.

Roadbed.....Graded portion of a street or alley prepared as the subgrade for construction of a pavement structure and shoulders.

Roadside .....Area adjoining the outer edge of a street.

Roadside Development.....Items necessary to preserve or replace landscape materials and features.

Shoulder .....Portion of the roadway adjacent to the traveled way that can accommodate stopped vehicles for emergency use and for lateral support of base and surface courses.

Shop Drawing .....Drawing furnished by the Contractor showing sufficient detailed information to build the object shown and described.

Sidewalk .....Portion of the right-of-way constructed exclusively for pedestrian use.

Sieve.....USA Standard Sieve, as defined in AASHTO M92.

Significant Change in Work .....Modification of a major work item (as defined elsewhere) from the original proposed construction.

Slope.....Inclination of a line or surface.

Special Provisions.....Additions, addendums, and revisions to the Standard and Supplemental Specifications applicable to an individual project.

Specialty Items.....Contract items requiring equipment, skills, or crafts not ordinarily associated with the types of work in the contract.

Specifications .....Written provisions and requirements to perform prescribed work.

Specified Starting Date.....Date upon which work must begin.

Stabilizing or Stabilization.....Incorporation of materials into soils or aggregates to increase load-bearing capacity, firmness, and resistance to weathering or displacement.

Standard Specification.....Written provisions and requirements approved for general application and repetitive use.

Standard Plan .....Detailed drawing approved for repetitive use.

Standard Plate .....Detailed drawing approved for repetitive use.

State .....State of Nebraska acting through the its authorized representatives.

Station (English) .....One hundred (100) linear feet.

Station (Metric).....One hundred (100) linear meters.

Street.....General term denoting a public way for purposes of vehicular travel, including the entire area within the public right-of-way.

Structure.....Building, bridge, pipe, culvert, fence, or other item not considered part of the roadway.

Subbase Course.....Layer or layers of specified material placed upon a subgrade to support a base or surface course.

Subcontractor .....Individual or legal entity separately contracted by the Contractor to perform specific work or portions of the work.

Subgrade.....Top layer of a roadbed upon which the pavement structure, shoulders, and curbs are constructed.

Subsidiary.....See Incidental.

Substantial Completion.....Major work items are satisfactorily completed and accepted in accordance with the Contract Documents and such major items of the project are occupied or otherwise utilized for the purpose for which they are intended.

Superintendent.....Representative of the Contractor charged with responsibility for the work.

Supplemental Agreement.....Written and signed agreement by all parties to the contract to perform work beyond the scope, but in conjunction with the original contract, including any prior modifications.

Supplemental Specification.....Approved addition or revision to the Standard Specifications.

Surety.....Individual or legal entity, other than the Contractor, executing a bond furnished by the Contractor.

Surface Course.....Pavement structure layer or layers constructed atop all other pavement layers and designed to accommodate the traffic load.

Surplus Material.....Reusable or otherwise valuable material present in the work but not used.

Target/Target Value.....Goal used for defining conformance.

Temporary Easement.....Strip of land within a larger area over which the property owner grants a temporary right-of-access to an individual or legal entity.

Temporary Pavement.....Pavement layers constructed to provide a temporary service to vehicular traffic.

Temporary Structure.....Structure required for maintaining traffic or access during the work and dismantled upon completion of the work.

Testing Laboratory.....Firm designated to perform testing on any or all work contained in the contract.

Through Street.....Street or road on which vehicular traffic is given preferential right-of-way and at the entrance to which vehicular traffic from intersecting streets or roads is required to yield right-of-way to vehicles on such streets or roads.

Traffic Control Device .....Sign, signal, marking, or device placed on, over, or adjacent to a street or highway by an authority of the public or official having jurisdiction to regulate, warn, or guide traffic.

Traffic Control Zone.....Distance from the first advance warning sign to the point after the work area where traffic is no longer affected.

Traffic Lane .....Portion of the traveled way designated for the movement of a single line of vehicles.

Traveled Way.....Portion of the right-of-way designated for vehicle use, excluding shoulders and auxiliary lanes.

Treated Subgrade.....Subgrade strengthened using a stabilizing agent.

Unacceptable Work.....See Defective Work.

Unauthorized Work.....Work not contemplated by the Contract Documents and not authorized by the Engineer or performed contrary to the instructions of the Engineer.

Unbalanced Proposal.....Proposal containing lump sum or unit bid items that do not reflect reasonable actual costs plus a reasonable proportionate share of the Bidder's anticipated profit, overhead costs, and other indirect costs.

Waterway .....A channel for the escape or passage of water.

Work .....Furnishing of all labor, materials, equipment, and other incidentals necessary or convenient to the successful completion of the contract and the carrying out of all duties and obligations imposed by the contract.

Work Order .....Written and signed order by the Engineer requiring performance by the Contractor without negotiation.

Working Day .....Any calendar day except:

- Saturdays, Sundays, or contract-designated holidays on which work is not performed unless otherwise designated in the Contract Documents;
- Contract-specified days suspending work; or
- Days where inclement weather or site conditions prevent the Contractor from performing a minimum of 4 hours of work towards the completion of the contract.

Working Drawing .....Drawing furnished by the Contractor showing sufficient detailed information to build the object shown and described.

2 – PROPOSAL REQUIREMENTS AND CONDITIONS

2.01 Qualification of Bidders.

Bidders, including all Subcontractors, shall be qualified to perform the work contained in the contract. Upon request, the Bidder shall furnish the City proof of such qualification that includes the following:

- Past experience on similar projects including, but not limited to, quality of work and materials, timeliness, and fair treatment of subcontractors;
- Number and quality of equipment available for use during the work;
- List of key personnel, including any related experience, available for use;
- Current contractual obligations, excluding the proposed work;
- Declaration of any fines, penalties, or other defaults occurring in the past five (5) years; and
- Financial responsibility consisting of a confidential statement or report of the Bidder's financial resources and liabilities as of the previous calendar or fiscal year and shall indicate if the current financial responsibility is approximately the same as stated or reported. A public accountant shall certify all statements or reports. If the Bidder's financial responsibility has changed, the Bidder shall qualify the statements or reports to reflect the true financial condition at the time of submitting such qualified statement or report.

Foreign corporations must submit proof of compliance, acceptable to the City, with the corporate laws of the State of Nebraska and proof of qualification to perform business with the State of Nebraska. Unless otherwise specified, the Bidder may submit evidence of pre-qualification by the State of Nebraska Department of Roads for the work present in the Contract Documents. Submit all requested information within fourteen (14) days of receipt of such request. Failure to comply will result in disqualification of the Bidder's proposal. The City shall keep all of the above requested information confidential.

2.02 Proposal Forms.

A Bidder must submit all bids on the proposal forms contained in the Contract Documents. The City shall furnish Bidders with proposal forms. All attachments are necessary to the proposal forms and must not be detached. Any plans, specifications, or other documents referenced in the proposal form are part of the proposal whether attached or not.

The City reserves the right to refuse to issue proposal forms to a prospective Bidder if such Bidder is in default for any of the following reasons:

- Failure to comply with the qualification requirements;
- Failure to pay or resolve, in a manner acceptable to the City, any or all just bills due for labor or materials on former contracts in force with the City at the time of Bidder requesting the proposal forms;
- Bidder has defaulted in previous contracts with the City; or

- Bidder has performed unsatisfactory work on previous contracts with the City.

The City shall not issue proposal forms to any Bidder after 4:30 P.M. Central Time of the day before the bid date.

2.03 Interpretation of Quantities.

The quantities contained in the proposal forms, unless otherwise indicated in the Contract Documents, are an estimate used for comparing proposals. The actual quantities of the work may vary. Unless otherwise indicated in the Contract Documents, payments to the Contractor will represent the actual work performed or materials furnished and accepted in accordance with the Contract Documents. The Bidder shall satisfy itself as to the accuracy of the estimated quantities.

The City reserves the right to increase, decrease, or omit the quantities of work or materials contained in the Contract Documents without invalidating the Bidder's contract prices, except as provided in Subsection 4.02.

2.04 Examination of Site of Work and Contract Documents.

The Bidder shall examine the site of work and all Contract Documents before submitting a proposal. The Bidder is responsible for satisfying itself as to the character, quality, and quantities of work and materials and requirements of the Contract Documents. Submission of a proposal is prima facie evidence that the Bidder performed such examination and the Bidder is satisfied as to the character, quality, and quantities of work and materials and requirements of the Contract Documents.

The City reserves the right to amend the Contract Documents before the bid date or bid time. Any such amendment will be by written addendum and issued to all prospective Bidders with the proposal forms furnished by the City by registered mail with return receipt requested or by hand delivery. The City reserves the right to issue an addendum at any time before the bid date or bid time. The City will advise Bidders of previously issued addenda when the Bidder requests the proposal forms. All addenda issued are part of the Contract Documents.

Failure of any Bidder to acknowledge receipt of all addenda in the space provided on the proposal form may result in rejection of such proposal.

Any Bidder submitting a proposal understands and accepts the terms and conditions contained in the Contract Documents. Any Bidder may submit a written request for interpretation of the Contract Documents. Addendum will provide any interpretation of such documents. Oral interpretations or explanations before the bid opening are non-binding.

When indicated in the Contract Documents, additional information pertaining to the proposed work, or site of work, may be available for examination by a prospective Bidder. Any assumptions, deductions, or conclusions made or obtained by the Bidder that are not implicitly identified by the City in the Contract Documents are for information only and are not part of the Contract Documents.

2.05 Preparation of Proposals.

The Bidder must submit a proposal on the bound proposal forms furnished to the Bidder by the City. The Bidder must fill all blank spaces correctly for every item necessary to complete the bid. The Bidder must fill all blank spaces indicating the contract prices, the value of the contract price multiplied by the appropriate estimated quantity, and the total amount of the base bid and any alternate bids. Failure to complete, properly and accurately, the proposal forms may constitute an irregular proposal and result in rejection of such proposal.

The Bidder must properly sign the proposal. An individual submitting a proposal shall provide their name and street address. A firm or partnership submitting a proposal shall provide the name and street address of each firm or partnership member. A corporation submitting a proposal shall provide the name of the state under which the corporation was chartered; the names, titles, and business addresses of the president, secretary, and treasurer; and legal evidence giving the appropriate authority to the signatory.

2.06 Alternates, Ties, Conditions, and Limitations.

A Bidder may submit an alternate bid only when requested on the proposal form. The City reserves the right to reject proposals containing qualifying statements, conditional bids, tied bids, incomplete bids, alternate bids, or other irregularities. Unbound or otherwise altered proposals may be considered irregular The City reserves the right to waive any and all irregularities and award a contract if it is in the "best interest of the City".

2.07 Unit Price Extensions.

The Bidder shall honestly attempt to show the correct extensions and the contract sum. If, in the opinion of the Engineer, the Bidder does not make such attempt, the Bidder shall consider such proposal rejected. The City shall not consider arithmetic errors in the proposal, in themselves, as cause for rejecting the proposal. Such errors shall be corrected and the corrected base bid sum or total base bid shall be the actual bid as submitted by the bidder. In the case of a discrepancy between the unit price bid and the extended line item total; the unit price bid shall govern and the extended line item total shall be corrected.

2.08 Proposal Guaranty.

A cashier's check, certified check on a national or Nebraska state bank, lawful money of the US, negotiable US Government Bond, or bid bond payable to the City of Omaha amounting to a minimum of five (5) percent of the proposal amount shall accompany each proposal.

2.09 Delivery of Proposals.

The proposal and accompanying guaranty must be in separate envelopes, each addressed to "City Council, City of Omaha", and attached to each other. The Bidder shall submit the proposal in a sealed envelope marked with the name and postal address of the Bidder and the name and any identification details of the project. The City will receive proposals until the bid date and bid time indicated in the Contract Documents at the address indicated below.

Office of the City Clerk, L/C 1
Omaha/Douglas Civic Center
1819 Farnam Street
Omaha, NE 68183.

The Bidder shall consider any proposals received after the bid date and bid time rejected. Upon receiving a written request from the Bidder, the City shall return any such proposals.

2.10 Withdrawal of Proposals.

Any Bidder may withdraw its submitted proposal anytime before the bid date and bid time provided the Office of the City Clerk receives the request for such withdrawal in writing. Withdrawal of a proposal does not prejudice the right of the Bidder to resubmit the proposal. Regardless of the exact time that the City opens the proposals, a Bidder cannot resubmit or withdraw a proposal after the bid time and bid date indicated in the Contract Documents has passed. The clock present in the City Clerk's office will display the official time for determining if the bid time has passed.

2.11 Public Opening of Proposals.

The City will open and publicly read the proposals on or immediately after the bid time and bid date at the location indicated in the Contract Documents. The City reserves the right to not open or read a proposal submitted without a proposal guaranty. Bidder errors present in the proposal are not cause for waiving the Contract Document requirements and are not the responsibility of the City. The City will only publicly read the total base bid and any alternate bids unless otherwise desired by the Public Works Department.

2.12 Disqualification of Bidder.

Any one or more of the following causes are sufficient for disqualifying a Bidder and rejecting any proposals by that Bidder.

- Reasonable ground for believing an individual or legal entity submitted more than one proposal on any one project under the same or different names;
- Evidence of collusion among Bidders;
- An unbalanced proposal; or
- Bidder submits a proposal incorrectly, incompletely, or on forms other than the proposal forms furnished to the Bidder by the City.

The City reserves the right to reject any or all proposals if there is reason to believe collusion exists among the Bidders. The City reserves the right to disqualify a Bidder(s) participating in collusion from submitting any proposals for any future work until the City agrees to allow the Bidder to submit a proposal.

2.13 Material Guaranty.

Before awarding any contract, the City reserves the right to request the successful Bidder furnish a complete statement of origin, composition, and manufacture of any material or equipment proposed for use in the work. The City also reserves the right to request a sample of the proposed material for the purposes of testing to determine compliance with the Contract Documents. The results of any preliminary testing do not guarantee acceptance of the materials if subsequent testing performed during the work indicates non-compliance with the Contract Documents.

THIS PAGE INTENTIONALLY LEFT BLANK

3 – AWARD AND EXECUTION OF THE CONTRACT

3.01 Consideration of Proposals.

After reading, the Engineer shall compare proposals based on the correct contract sum. Comparison results will become public one (1) working day after the bid date and bid time except when all proposals exceed the Engineer's estimate. The City reserves the right to reject any or all proposals and to waive any informalities, irregularities, minor defects, or technical errors as may be deemed best for the interests of the City.

3.02 Award of Contract.

The City Council will award the contract to the lowest responsible Bidder whose proposal complies with the requirements contained in the Contract Documents and represents the "best interests of the City". The City may investigate the responsibility of a Bidder before awarding the contract. The City reserves the right to limit the work awarded to one Contractor. The City shall base such limit upon the amount, in the opinion of the City, the Contractor is capable of handling, taking into account the Contractor's capacity to perform the work and the current contracts in force. The City shall notify the successful Bidder by mailing an award letter to the address shown on the proposal.

In accordance with State of Nebraska law for street or storm sewer contracts, if the City does not receive a proposal less than the Engineer's estimate, the City shall not award the contract for fifteen (15) calendar days from the bid date. In this fifteen (15) day period, any individual or legal entity may submit a proposal and proposal guaranty to the Public Works Director to perform the work for an amount less than the Engineer's estimate. At the completion of the fifteen (15) day period, the City reserves the right to award the contract to the lowest qualified Bidder at that time.

3.03 Cancellation of Award.

The City reserves the right to cancel any contract award, without any liabilities against the City, before all parties execute the contract.

3.04 Return of Proposal Guaranties.

Upon the City Council awarding the contract to the lowest responsible Bidder, all other proposals will stand rejected. The City will return the proposal guaranty for the unsuccessful proposals at that time. The City will return the successful Bidder's proposal guaranty upon approval of the contract and bond.

3.05 Requirements with Respect to Contract Bond.

The successful Bidder shall furnish a contract, performance, payment, and guarantee bond within ten (10) days on the forms furnished by the City. The bond shall be for the full amount of the contract. The bond shall be a security for the faithful performance of the contract, payment of personnel and materials, and the work guarantee required by the contract for the period of guarantee stated in Subsection 8.11. A corporation authorized to contract as a Surety in the State of Nebraska and satisfactory to the City must execute any bonds.

3.06 Execution of Contract.

The successful Bidder shall sign and return the contract within ten (10) days from the award date. The City must receive the satisfactory bonds, certificates of insurance, and other required documents before executing the contract. No proposal shall be considered binding upon the City until execution of the contract.

The signatory of a corporation, other than the president, must submit a resolution of the directors of the corporation, imprinted with the corporation seal, acknowledging the right to sign for the corporation. The signatory must attach a copy of the resolution to the executed contract.

3.07 Failure to Execute Contract.

The City may annul the award and cancel the proposal if:

- The successful Bidder fails to execute the contract and/or submit the required bonds within ten (10) days from the date of award; or
- The successful Bidder fails to demonstrate compliance with Subsection 2.01 within fourteen (14) calendar days from the receipt of such request.

Annulment of the award and cancellation of the proposal will result in forfeiture of proposal guaranty to the City, not as a penalty but in liquidation of damages sustained not susceptible to easy or exact ascertainment. The City reserves the right to proceed with the execution of the contract with the successful Bidder upon receipt of all the required documents.

3.08 Notice to Bidders.

The Public Works Department, City of Omaha, in accordance with the provisions of the City's Affirmative Action Program, hereby notifies all Bidders that it will affirmatively ensure that the contract entered into will be awarded to the lowest responsible Bidder without discrimination because of race, religion, age, political affiliation, color, sex, or national origin.

4 – SCOPE OF WORK

4.01 Intent of Contract.

The contract's intent is to provide for the construction and completion in every detail of the work described. The Contractor shall furnish all labor, materials, equipment, tools, transportation, supplies, and all incidentals required to complete the work in accordance with the Contract Documents.

The Engineer will provide the Contractor one (1) complete copy of the Contract Documents. The Contractor shall have this complete copy available on the work site at all times. The Engineer will provide six (6) copies of all plans, specifications, and addenda at no cost to the Contractor. The Engineer may furnish additional copies for a fee.

4.02 Alteration of Plans or Character of Work.

The Engineer reserves the right to alter the following:

- Contract item quantities;
- Construction details; or
- Roadway, sewer, structure, or facility grade or alignment.

Alterations will not waive or invalidate any contract provisions. If the alteration increases or decreases the total original estimated contract sum by twenty-five (25) percent or more, the City may execute a supplemental agreement with the Contractor. Work on an alteration requiring a supplemental agreement shall not begin until all parties have executed such agreement.

Upon submitting a proposal, the Contractor acknowledges that the quantities contained in the proposal forms, unless otherwise indicated in the Contract Documents, are estimates that may vary. No claims for anticipated profit, profit loss, or any other damage due to variation between the proposal and the actual quantities are allowed. The City reserves the right to partially or entirely eliminate one or more contract items from the proposal.

4.03 Extra Work.

The Contractor shall perform extra work in accordance with the Contract Documents or as directed by the Engineer. The Engineer must recognize the extra work in writing before the Contractor performs such work. The Engineer shall provide the Contractor an Extra Work Order indicating the mutually agreed upon payment format before extra work is performed. If no such payment format exists, the Contractor will perform extra work as force account work. The Contractor has the right to appeal an Engineer's judgement of whether work done by the Contractor constitutes extra work. Such appeals must be in writing. The Contractor must submit the appeal no later than seven (7) calendar days after completing such work. The

Engineer reserves the right to halt work performed under an extra work order in accordance with these specifications.

4.04 Maintenance of Detours.

Unless otherwise indicated in the Contract Documents, the Contractor shall not close a traveled way without the express permission of the City Traffic Engineer. The City shall provide and maintain detours around the work unless otherwise indicated in the Contract Documents. When indicated in the Contract Documents, the Contractor shall assume all responsibility for providing and maintaining detours around the work. The City or Contractor shall close or open detour routes in accordance with the requirements of the City of Omaha Barricading Standards, Specifications, Methods, and Materials.

The Contractor shall provide access to local traffic within the project, as practicable, in accordance with the Contract Documents or as directed by the Engineer. The Contractor is responsible for maintaining any temporary approaches or crossings.

4.05 Removal and Disposal of Surplus Materials, Discarded Materials, Rubbish, Debris, Structures, and Obstructions.

Unless otherwise indicated in the Contract Documents, the Contractor shall remove any existing structures that are not to remain in place. Existing structures are to remain in place until the replacement structures are complete unless such existing structures interfere with the work. As directed by the Engineer, any materials deemed fit for use elsewhere shall remain the property of the City. The Contractor shall remove such materials without damage in readily transportable sections.

The City reserves the right to retain ownership of all surplus materials. As directed by the Engineer, the Contractor shall deliver any retained surplus materials to a designated City facility. The Contractor shall remove and dispose of any obstructions or surplus materials encountered and not retained by the City at no additional expense to the City. The Contractor shall thoroughly wash any pavement, walks, gutter lines, or other constructed items to remove soil or other foreign materials throughout the course of the project as directed by the Engineer.

The Contractor shall remove and dispose of all discarded materials, rubbish, or debris at no additional expense to the City in accordance with all Local, State, and Federal regulations and laws.. The Contractor shall remove such material within twenty-four (24) hours of the Engineer requesting that the Contractor remove the materials. The City may remove from the site, at the Contractor's expense, any surplus or discarded materials (including existing manholes and inlets on site), rubbish, or debris remaining after twenty-four hours.

The Contractor shall mow all areas of the project where vegetation growth exceeds eighteen (18) inches in height at no additional cost to the City. The Contractor shall cut such vegetation as close to the ground as possible. The Contractor shall rake and remove the cuttings from the premise immediately.

4.06 Rights In and Use of Materials Found on the Project.

The Contractor may use stone, gravel, or other materials found within the excavation limits as designated by the Engineer or the Contract Documents. All materials are subject to approval by the Engineer. Payment for the excavation of such items will be at the corresponding contract price therefor. The Contractor shall replace such material as was contemplated for use in embankments, backfill, approaches, or otherwise with other suitable material at no additional expense to the City. The Contractor shall not excavate or remove any material outside of the excavation limits without written authorization from the Engineer.

The Engineer may permit the temporary use of material from an existing structure for erection of a new structure unless otherwise indicated in the Contract Documents. The Contractor shall not use such material without approval of the Engineer.

4.07 Final Clean Up.

Upon completion of the work, the Contractor shall leave the project site in a neat and presentable condition as determined by the Engineer. At a minimum, the Contractor shall remove all rubbish, excess materials, falsework, temporary structures, equipment, and any other items not included in the final project. The Contractor shall dispose of any trees, stumps, or other removed materials placed on properties adjacent to the project as indicated in these specifications. The Engineer shall not authorize final payment and acceptance of the work until such conditions are met.

THIS PAGE INTENTIONALLY LEFT BLANK

5 – CONTROL OF WORK

5.01 Authority of the Engineer.

The Engineer is the final authority regarding all questions concerning the quality or acceptability of the work. Decisions made by the Engineer are final. The Engineer has executive authority to enforce the Contract. The Engineer reserves the right to suspend all or any part of the work at any time.

5.02 Plans and Working Drawings.

Working drawings will supplement the approved plans as needed to describe the work adequately. All working drawings must be clear and in a format acceptable to the Engineer. The Contractor is responsible for furnishing five (5) copies of the working drawings, unless otherwise directed by the Engineer, at no additional cost to the City. Preliminary working drawings are not acceptable. When requested by the Engineer, the Contractor shall provide reproducible prints of the working drawings at no additional cost to the City. Reproducible prints must be electronic in AutoCAD format or unfolded paper copies.

The Engineer must approve the working drawings before the Contractor performs the work described by the working drawings. A Professional Engineer certified in the State of Nebraska must design and stamp working drawings describing structural work as required by the Engineer. All working drawings shall identify the name of the individual or legal entity that prepared the drawing(s). Upon approval of the working drawing(s), the Engineer shall return two (2) copies to the Contractor. The Engineer must approve changes to the working drawings in writing. The Engineer's approval of the working drawings does not relieve the Contractor of any responsibility as defined by these specifications.

5.03 Conformity with Plans and Allowable Deviations.

The Contractor shall provide all work and materials in conformance with the Contract Documents. The Contractor has the right to propose alternate materials or operations unless otherwise indicated in the Contract Documents. The Engineer must approve all proposed alternative materials or operations. Materials or operations referred to by well-known technical or trade names shall provide recognized standards for comparing alternative materials or operations. Alternative materials or operations must be equal to or better than the materials or operations referenced in the Contract Documents.

The Engineer may accept work in reasonably close conformance with the Contract Documents. The Contractor shall not construe reasonably close conformity as waiving the Contractor's responsibility to complete the work in accordance with the Contract Documents. The Contractor shall not

construe reasonably close conformity as waiving the Engineer's right to require strict conformance with the Contract Documents.

The Contractor shall rework or remove and replace all materials or work not in conformance with the Contract Documents at no additional expense to the City. The Engineer reserves the right to accept work not in conformance as deficient work accepted at a reduced contract price. The Engineer shall determine the reduced contract price. The Engineer shall alter the contract by change order to reflect the reduced contract price.

5.04 Coordination of the Contract Documents.

All parts of the Contract Documents are essential and a requirement in one part is as binding as though occurring in all. The Contract Documents are complementary. They describe and provide the complete contract for the work. The Contractor may not take advantage of any apparent contract errors or omissions. The Contractor shall notify the Engineer promptly of any omissions or errors. The Engineer shall make any corrections or interpretations necessary to fulfill the intent of the Contract Documents. In the case of a discrepancy between parts of the Contract Documents, the following rules shall govern:

- Plans overrule all other Contract Documents.
- Computed dimensions overrule scaled dimensions.
- Special provisions overrule supplemental and standard specifications.
- Special plans overrule standard plans.
- Supplemental specifications overrule standard specifications.

5.05 Cooperation of the Contractor.

The Contractor shall cooperate with the Engineer, any Project Representatives, and other Contractors at all times. The work shall proceed at a reasonable rate towards completion. The Contractor shall designate one (1) competent Superintendent, employed by the Contractor, to coordinate and communicate with the Engineer. The Superintendent shall remain on the project site at all times during the work, regardless of the individuals or legal entities performing the work. The Superintendent shall be experienced, capable of understanding the plans and specifications, and have the authority to execute any order or direction given by the Engineer. The Superintendent is responsible for supplying any materials, equipment, labor, or other incidentals necessary to complete the work. The Engineer reserves the right to halt the work if the Superintendent is not present during the work.

5.06 Cooperation with Utilities.

The Contractor is responsible for notifying all utility companies, pipeline owners, or other parties affected by the work. The Contractor shall contact

the State of Nebraska "One-Call" system for assistance in locating all utilities, pipelines, and other installations in the project. The Contract Documents will identify known utility items that the utility owner(s), others, and/or the Contractor will adjust or relocate. The Contract Documents may not identify all utilities, pipelines, or other installations. The Contractor shall cooperate with the utility owners to remove and rearrange underground or overhead utilities to avoid service interruption or duplicate work by the utility owner. The Contractor shall use work procedures that protect utilities or appurtenances that remain in place during construction.

Upon submitting a proposal, the Contractor agrees that consideration of the location of all identified or unidentified utilities is included in the contract price. Further, the Contractor agrees that the City will not provide any additional compensation due to delays, inconvenience, or damages sustained by interference from said utilities or appurtenances or the operation of relocating said utilities. The Contractor shall perform minor grade adjustments of valve boxes on privately-owned service lines involving telescoping the threaded section of the valve box at no additional cost to the City.

The Contractor shall notify the appropriate utility of any service interruption resulting from breakage within the construction limits, or otherwise by the Contractor's operations, and cooperate during service restoration. The Contractor is responsible for correcting and/or paying for repairs for damage to utilities resulting from the Contractor's operations. The Contractor shall restore damaged facilities to the pre-existing condition.

The Engineer will decide whether to adjust or relocate utility facilities or appurtenances found but not noted in Contract Documents. The Engineer shall make any necessary arrangements with the utility owner or the Contractor to perform any necessary unidentified work not indicated in the Contract Documents. The Engineer will use the provisions of the Contract Documents to make compensable or noncompensable adjustments to the Contract because of revised or added work.

5.07 Cooperation between Contractors.

The City reserves the right to contract or perform work on or near the work covered by the Contract Documents. The Contractor shall perform the work in a manner that does not hinder or interfere with the progress of other work performed under a separate contract in the project. The Contractor shall join such work in an acceptable and proper manner and sequence to that of others. The Contractor shall place and dispose of materials so as not to interfere with the work of other Contractors or City forces within the project. The Engineer shall decide any disputes that arise during performance of separate contract work. The decision of the Engineer in these matters is final.

The Contractor is financially or otherwise liable for work contained under the Contract. The Contractor shall protect and save harmless the City from any damages or claims that may arise due to inconvenience, delay, or loss incurred by the Contractor because of the presence and operations of other Contractors working within the limits of the project. The Contractor assumes all responsibility for any work not completed or accepted due to the presence and operations of other Contractors.

5.08 Construction Stakes, Lines, and Grades.

The Contractor shall construct the work in accordance with the stakes and marks. The Contractor is responsible for the work conforming to such stakes and marks. The Engineer will furnish and set construction reference stakes necessary, in the opinion of the Engineer, to construct the work. At a minimum, the stakes will identify roadway profile, grade, and lines; sewer centerlines; and benchmarks for bridgework. Upon request, the Engineer will furnish and set construction reference stakes that determine the centerlines of all bridge substructure units and angles of wings or retaining walls. The Contractor shall not perform any work until the Engineer has furnished the proper lines and grades.

The Contractor shall make every effort to preserve all stakes and marks provided by the Engineer. The Contractor is responsible for the cost to reset stakes or marks that have been, in the opinion of the Engineer, carelessly or willfully destroyed or disturbed. The cost for resetting stakes and marks includes the time and material costs to the City. The City will deduct such costs from payments due to the Contractor.

The Contractor must notify the Engineer seven (7) calendar days before needing any initial construction reference stakes and marks. After the initial construction reference stakes and marks are set, the Contractor shall provide the Engineer forty-eight hours (48) notice for any additional construction reference staking or marking.

5.09 Authority and Duty of the Project Representative.

The City may designate one or more Project Representatives to observe the work. The City authorizes the Project Representatives to check all work and materials furnished. The City does not authorize the Project Representative to revoke, alter, or waive any requirements of the Contract Documents. The Project Representative may notify the Contractor of work or materials that the Engineer may deem unacceptable. The Contractor shall not authorize the Project Representative to supervise or otherwise interfere in the management of the work.

5.10 Inspection.

The Engineer reserves the right to inspect any part of the work or materials used in the work at any time. The Contractor is responsible for providing

quality materials, workmanship, and processes in strict compliance with the Contract Documents. The Contractor shall provide the Engineer access to all parts of the work and all material fabrication facilities related to the project. The Contractor shall provide any information required by the Engineer to perform a complete and detailed inspection.

The Engineer reserves the right to request that the Contractor remove or uncover portions of the finished work for inspection. Upon inspection, the Contractor shall replace or recover such portions of the finished work in accordance with the Contract Documents. The cost for removing, uncovering, replacing, or recovering such portions of the finished work is incidental to the work.

The Engineer reserves the right to reject any part of the work performed without a Project Representative present.

5.11 Removal of Unacceptable Work and Materials.

The Contractor shall remove and replace all unacceptable work or materials unless otherwise indicated by the Engineer. The Contractor is responsible for the cost of removing and replacing such work or materials. Any work or extra work performed by the Contractor contrary to the instructions of the Engineer, without the approval of the Engineer, or beyond the lines or grades provided by the Engineer or in the Contract Documents is unauthorized. The City may not pay for unauthorized work and may require the Contractor to remove or replace such work at no expense to the City. The Engineer reserves the right to authorize another individual or legal entity to remove any unacceptable or unauthorized work or materials. The Engineer shall deduct the cost of such removal from monies due or that become due to the Contractor.

5.12 Restrictions on Moving and Use of Heavy Equipment.

All trucks and other equipment using pavement or structures must comply with the laws governing the operation of such equipment on the streets of the City. The Contractor is responsible for any damage resulting from the operations of such equipment. Special permits do not relieve the Contractor of such responsibility.

The Contractor may operate pneumatic tire earth moving equipment on PCC, BST, or ACC surface or base provided the tire pressures and load on any single axle are less than or equal to forty (40) psi and twenty thousand (20,000) pounds, respectively. The Contractor shall not operate any machines with metal lugs or other projections on the treads on ACC, PCC, or BST surface or base.

The Engineer must approve any equipment operation on new pavement. All equipment shall maintain a horizontal distance of two (2) feet or greater from the edge of such pavement. Approval by the Engineer does not relieve

the Contractor of liability for any damage incurred due to operation of such equipment. All equipment operating on new pavement shall move on and off the pavement using a ramp comprised of materials acceptable to the Engineer. The ramp shall support the equipment in a manner to prevent any impact loading on the edge of the pavement or curb.

The Contractor shall obtain all necessary oversized and/or overweight permits for all equipment used on the project at no additional cost to the City. All track-mounted equipment shall cross bridges only at a speed and location relative to centerline acceptable to the Engineer.

The Contractor shall position any material transfer vehicles to prevent excessive pressures on a single wheel or support. The Contractor shall not operate or position any dragline, power shovel, or crane on any surface or base pavement layer.

5.13 Use of Adjacent Land under Contract or Lease.

The Contractor shall confine all operations to within the limits of easements secured for the project. The Contractor is responsible for obtaining and understanding the terms of any easements. Information on any easement is available at the City of Omaha Public Works Department. The Contractor shall leave any lands used in accordance with an easement in a neat and presentable condition acceptable to the Engineer.

5.14 Final Inspection.

The Contractor shall notify the Engineer in writing that the work contained in the Contract Documents is complete. The Engineer shall inspect the work within fifteen (15) calendar days of receiving such notice. The Engineer will notify the Contractor in writing of any parts of the work that are unacceptable. The Engineer, upon accepting the work, shall approve the final payment for the work. Final payment for the work does not release the Contractor and/or the Surety from the terms of the guarantee bond in accordance with Subsection 8.11.

6 – CONTROL OF MATERIALS

6.01 Material Source and Delivery.

Materials shall conform to the requirements outlined in the Contract Documents.

6.02 Local Material Sources.

The City may acquire the right to obtain materials from designated sources. The City also reserves the right to acquire use of property adjacent to the project. Such materials or properties shall be available for use by the Contractor as indicated in the Contract Documents. The Contractor shall leave any available properties in a condition acceptable to the Engineer in accordance with the Contract Documents.

6.03 Samples, Tests, and Cited Standards.

The Engineer reserves the right to inspect or test, at any time, any materials for compliance with the Contract Documents. Unless otherwise indicated in the Contract Documents, the Engineer shall designate a qualified individual or legal entity to perform any sampling or testing of materials. The methods of testing shall be as indicated in the City of Omaha Materials Testing Manual. Referenced test standards shall be the most current version available on the date of the first advertisement unless otherwise indicated in the Contract Documents.

Testing performed by the Engineer shall not relieve the Contractor of the responsibility to furnish materials complying with the Contract Documents. The City reserves the right to retest materials to verify compliance with the Contract Documents. If the retest indicates such materials do not comply with the Contract Documents, the Engineer may reject such material.

6.04 Plant Inspection.

The Engineer reserves the right to inspect any material at the source. The Contractor shall provide the Engineer any cooperation, information, access, and assistance required by the Engineer. The Contractor shall provide representative samples of any material to the Engineer upon request. The Contractor shall provide a facility at the material source for use by the Engineer as required by the Contract Documents. The Engineer reserves the right to inspect materials at the source and at the project.

6.05 Facilities for Field Inspection and Testing.

When indicated in the Contract Documents or by the Engineer, the Contractor shall furnish a field facility for exclusive use by the Engineer. The facility shall be in a location acceptable to the Engineer. At a minimum, the facility shall have the following characteristics:

- All weather-proof, enclosed rigid frame, roof, floor, and wall structure with heat, air conditioning, and power;
- Minimum of one (1) window (24" x 36" minimum dimensions, lockable)
- Minimum floor area of one hundred (100) square feet;
- Minimum width and floor to ceiling height of seven (7) feet;
- Dust and weather tight;
- Minimum one (1) desk, one (1) file cabinet, and three (3) chairs; and
- Lockable door; and
- Placed level and solidly supported to eliminate vibration.

6.06 Material Delivery, Storage, and Handling.

The Contractor shall handle and store materials to preserve their quality and avoid segregation or contamination. The Engineer may allow the Contractor to store materials on City property as directed by the Contract Documents. The Contractor shall restrict operations on City property to the areas authorized by the Engineer. The Contractor shall hold and save the City and its personnel free and harmless from any liability because of unauthorized use, trespassing, or damage to equipment or materials stored on City property.

The Contractor shall protect all materials, regardless of the manner of protection, at no additional cost to the City. The Contractor shall store materials covered on a hard, clean surface when directed by the Engineer. The Contractor may construct a temporary storage building on the project only with written permission from the Engineer. Any temporary storage installations are the property of the Contractor. The Contractor shall remove such installations at the completion of the work.

The Contractor may store materials or equipment within the right-of-way at locations determined by the Engineer. The Contractor shall restore or repair any damage to such storage areas upon completion of the work. The Contractor shall obtain any additional storage space necessary at no additional cost to the City.

The Contractor must keep any vehicle transporting material clean and in proper working condition. Such vehicles must transport materials in a manner to prevent the loss of materials.

6.07 Unacceptable Materials.

The Engineer reserves the right to reject any materials not conforming to the requirements of the Contract Documents. The Contractor shall remove any unacceptable materials from the project. The Engineer shall cause removal of any unacceptable materials not removed by the Contractor. The Engineer shall deduct the cost of such removal from monies due to the Contractor.

6.08 City Furnished Materials.

The Contractor shall furnish all materials necessary to complete the work except those materials furnished by the City as indicated in the Contract Documents. The City shall deliver or make available such materials as directed in the Contract Documents. The Contractor shall include the cost of obtaining, handling, and placing furnished materials in the contract price for the related items. The Contractor is responsible for all furnished materials given to the Contractor by the City. The Contractor shall bear the replacement cost of furnished materials due to loss or damage not the fault of the City.

6.09 Excess Material Disposal

All excess materials removed from the project site(s) shall be disposed of at locations acceptable to the City of Omaha. The Contractor shall identify in writing the location of his disposal site and provide this to the Engineer at the pre-construction meeting. During the project construction, the Contractor shall keep the Engineer informed of all disposal dates, locations, and approximate material quantity.

THIS PAGE INTENTIONALLY LEFT BLANK

7 – LEGAL RELATIONS AND PUBLIC RESPONSIBILITY

7.01 Laws to be Observed.

The Contractor shall observe and comply with all Federal, State, and Local laws and ordinances and regulations, orders, and decrees of bodies or tribunals having any jurisdiction or authority. The Contractor shall protect and indemnify the City and its representatives against any claim or liability originating from violating any of the above items by the Contractor, Subcontractor(s), suppliers of materials or services, or any others engaged by the Contractor. The Contractor shall immediately notify the Engineer in writing upon discovering any discrepancy or inconsistency between the Contract and any law, ordinance, regulation, or order, except as noted in Subsection 7.05.

7.02 Permits, Licenses, and Taxes.

The Contractor shall give all notices; obtain all permits and licenses; and pay all charges, fees, and taxes necessary to the work. The cost of such items is incidental to the work. The Contractor and all Subcontractor(s) shall pay City of Omaha registration (popularly called the "Wheel Tax") on all applicable equipment used on the project as defined in Chapter 16 of the Omaha Municipal Code. The Contractor shall submit acceptable evidence of such payments upon request of the Engineer. Nebraska State Statutes require every individual or legal entity furnishing labor or material for any public improvement project to furnish a current certified tax assessment statement, giving the county assessed, for all equipment used on the project. The Contractor may exclude equipment acquired after the latest assessment date of such requirement. The Contractor shall furnish such statement before the City makes final payment.

7.03 Patented Devices, Materials, and Processes.

The Contractor agrees that contract prices include all royalties and costs associated with patents, trademarks, and copyrights. The Contractor and the Surety shall indemnify and save harmless the City from any claims for infringement due to use of any such patented, trademarked, or copyrighted items connected to the work. The Contractor shall indemnify the City, its representatives, and any affected third party or political subdivision from claims for any costs, expenses, and damages obligated due to such infringement.

7.04 Restoration of Surfaces Opened to the Public.

The Contractor shall allow any party bearing a duly authorized and satisfactory permit from the City to make openings in the street. When directed by written order from the Engineer, the Contractor shall perform all necessary repairs due to such openings. The Engineer shall consider such repairs extra work.

7.05 Federal and State Participation.

The United States Government and/or the State reserve the right to inspect and approve the work for a federally assisted contract. The Contract Documents shall supersede conflicting provisions of Federal laws, rules, or regulations. The United States Government and/or the State, however, are not a party to the contract and will not interfere with the rights of parties to the contract.

7.06 Sanitary Provision.

The Contractor shall provide and maintain employee toilets in a neat and sanitary condition complying with the Federal, State, and Local requirements. The Contractor shall locate such toilets on the project site.

7.07 Public Convenience and Safety.

The Contractor shall manage the work in accordance with the Contract Documents. The Contractor shall ensure the safety and convenience of the public and property as provided under Subsection 4.04. The Contractor shall follow the safety provisions of any applicable laws, rules, codes, and regulations. If the travelling public uses a road under construction, the Contractor shall maintain the subgrade and the new pavement in a safe condition acceptable to the Engineer. The Contractor shall provide flag persons in accordance with the requirements of the City of Omaha Barricading Standards, Specifications, Methods, and Materials. The cost for providing flag persons is incidental to the work unless otherwise indicated in the Contract Documents.

7.08 Barricades, Danger, Warning, and Detour Signs.

The Contractor shall provide, erect, and maintain all traffic control devices in accordance with the traffic control plan. The Engineer reserves the right to require additional traffic control devices. All traffic control devices shall conform to the current version of the Manual for Uniform Traffic Control Devices and the City of Omaha Barricading Standards, Specifications, Methods, and Materials. The Engineer shall approve any dismantling or removal of traffic control devices. The cost of providing, erecting, and maintaining all traffic control devices is incidental to the work unless otherwise specified in the Contract Documents. The Engineer may suspend the work in accordance with Subsection 5.01 if the Contractor fails to fulfill the requirements of this subsection.

7.09 Preservation and Restoration of Property.

The Contractor is responsible for preserving public and private property during the work. The Contractor shall ensure that the Engineer affirms the location of monuments, property line markers, or other items before moving, disturbing, or damaging them. The Contractor assumes liability for

any damage to public or private property resulting from defective work or materials, or non-execution of the contract. The Contractor shall maintain liability insurance or responsibility until the Engineer accepts the work. The Contractor shall restore any damaged property to a condition similar or equal to that existing before the damage at no additional cost to the City. The Contractor shall temporarily discontinue work upon encountering any potential remains of prehistoric dwelling sites or artifacts of historical or archeological significance. The Engineer will contact the State archeological authorities who will determine the item's disposition. When directed, the Contractor shall excavate the site to preserve the artifacts and remove them to the custody of the State authorities. The Engineer shall consider such work extra work.

7.10 Right-of-Way.

The City shall furnish the right-of-way and easements as indicated in the Contract Documents at no cost to the Contractor.

7.11 Responsibility for Damage Claims.

The Contractor shall indemnify and save harmless the City and its representatives from all actions and claims from injury or damage to persons or property resulting from the action or omission of the Contractor's employees or agents. The Contractor is responsible for any property damage or injury to persons during prosecution of the work resulting from defective work or materials or any act, omission, neglect, misconduct, or non-execution of the work. The Contractor shall obtain and maintain liability insurance for damages imposed by law, of the type and amount specified in Subsection 7.12, until acceptance of the Work. The Contractor shall ensure coverage of all operations under the contract, whether performed by the Contractor or Subcontractor.

7.12 Insurance.

The State of Nebraska Department of Insurance must license the Insurer. The Contractor and any Subcontractor(s) shall furnish certificates of insurance for Workers Compensation and Liability and Property Damage Insurance in at least the following amounts:

- Workers Compensation: Statutory Requirements of the State of Nebraska;
- Bodily injury liability: $500,000 each person, $1,000,000 each occurrence for contracts $200,000 and under. $1,000,000 each person and $5,000,000 each occurrence for contracts over $200,000; and
- Property damage liability: $500,000 each occurrence, $1,000,000 aggregate.

The Contractor and any Subcontractor(s) shall carry fire insurance against loss or damage by fire and against loss or damage covered by the standard

extended coverage insurance endorsement including vandalism and malicious mischief. The amount of coverage shall be equal to the value of work and materials furnished. The Contractor shall provide additional insurance as required by the Contract Documents. The Contractor and any Subcontractor(s) shall maintain all insurance until acceptance of the work.

Insurance policies shall bear an endorsement or have an attached rider indicating the Insurer shall notify the City by registered mail, return receipt requested, in case of expiration or proposed cancellation of such policies no less than ten (10) days before the expiration or cancellation is effective. The cost of providing insurance is incidental to the work unless otherwise indicated in the Contract Documents.

7.13 Opening Sections of the Project.

The Engineer reserves the right to accept, tentatively and in writing, a portion of the work and open said portion to traffic. The Contractor's responsibility for maintenance and public liability of the said portion shall cease if the Contractor removes all materials and equipment from the right-of-way. The Contractor shall not construe acceptance of a portion of the work as final acceptance of all work. Acceptance of a portion of the work does not relieve the Contractor of responsibility for damages due to defective work or non-compliance with the Contract Documents. The Contractor is responsible for any non-ordinary, in the opinion of the Engineer, traffic damages for portions of the work opened to traffic before completion or tentative acceptance. If the Contractor ceases operations and removes all equipment and materials from the right-of-way, the Engineer shall relieve the Contractor of public liability.

7.14 Contractor’s Responsibility for Work.

The Contractor is responsible for protecting the work from damage due to weather or other causes until the Engineer accepts the work in writing including any time that the work is suspended. The Contractor shall properly protect and maintain all living material in plantings, seeding, and sod furnished under the contract until the Engineer accepts the work in writing including any time that the work is suspended. The Contractor shall correct any damage at no additional cost to the City before final acceptance by the Engineer. The Contractor is not responsible for damage, in the opinion of the Engineer, due to unforeseeable causes beyond the Contractor's control including but not restricted to Acts of God.

The Contractor shall exercise every reasonable precaution to prevent silting of waterways. The Contractor shall construct drainage facilities and erosion control measures simultaneously with earthwork operations to minimize erosion and silting. Erosion control measures shall continue until permanent drainage facilities are constructed and, in the opinion of the Engineer, vegetation growth has established on seeded slopes. The

Contractor shall remove any obstructions placed in rivers, streams, or drainageways upon completing the work.

The Contractor shall exercise every reasonable precaution to prevent pollution of waterways or water impoundments with harmful materials. The Contractor shall comply with all applicable Federal, State, and Local laws and ordinances and regulations, orders, and decrees of bodies or tribunals having any jurisdiction or authority relating to pollution. The Contractor shall deposit any waste excavation in a location acceptable to the Engineer that avoids erosion of such materials by high water or runoff.

7.15 Contractor's Responsibility for Utility Property and Services.

The Contractor shall not commence the work until making all arrangements necessary for the protection of railways and telegraph, telephone, power lines, and other utilities. The Contractor shall immediately notify the utility company of an accidental interruption in service. The Contractor shall cooperate with utility companies to facilitate the removal or relocation of utilities with minimal duplication or service interruption and reasonable progress. The Fire Department shall have access to fire hydrants at all times. The Contractor shall not store or stockpile any materials within fifteen (15) horizontal feet of an active fire hydrant. The Contractor shall schedule a reasonable amount of time for the utility company to complete any work required.

7.16 Personal Liability of Public Officials.

The authorized representatives of the City act solely as representatives of the City when conducting and exercising power or authority granted them under the contract. There is no liability on them either personally or as City employees.

7.17 No Waiver of Legal Rights.

Final acceptance does not preclude the City from correcting any measure, estimate, or certificate made before or after contract completion. The City may recover from the Contractor or Surety, or both, overpayments upheld for failure to fulfill contract obligations. A waiver on the part of the City of any breach of any part of the contract is not a waiver of any other or subsequent breach. The Contractor shall assume liability for latent defects, fraud, or such gross mistakes as may amount to fraud, or as regards the right of the City under any warranty or guaranty without prejudice to the terms of the contract.

7.18 Use of Explosives.

The Contractor shall ensure that the use of explosives does not endanger life, property, or new work. The Contractor shall assume liability for

property damage, injury, or death resulting from the use of explosives. The Contractor shall notify property owners and public utility companies near the proposed detonation before using any explosives.

7.19 Third-Party Beneficiary Clause.

The parties executing this contract specifically agree that the intent of the contract is not to create any individual or legal entity as a third-party beneficiary. Furthermore, the contract does not authorize any individual or legal entity not party to the contract to maintain an action for damages under said contract provisions.

7.20 Hazardous Material.

In the event the Contractor encounters material on site reasonably believed to be a CERCLA hazardous substance in concentrations that may constitute a substantial hazardous waste as defined in 40 CFR Part 261 that has not been rendered harmless, the Contractor may test (at the Contractor's expense) the suspected material using the appropriate EPA technology. If the material is determined to be hazardous, the Contractor shall immediately stop work in the affected area, safely secure the work site, and immediately notify the Engineer. The Contractor shall continue work in other areas of the project unless otherwise directed.

The Contractor shall treat abnormal conditions with extreme caution. The Contractor shall meet the requirements and regulations of all applicable Local, State, and Federal Agencies when handling, transporting, and disposing of hazardous material or toxic waste.

Unless specifically addressed in the contract documents, handling, processing, and/or disposing of such hazardous material shall be considered outside of the scope of the contract. Additional work associated with handling, processing, and/or disposing of the hazardous waste or materials will constitute Extra Work as defined in section 4.03.

The City of Omaha shall not consider the Contractor the "Generator, Owner, or Responsible Party" for any hazardous waste or hazardous material discovered in the normal performance of work associated with this contract, nor during the performance of any "Extra Work" unless such material has been brought to the site by the Contractor.

The Contractor shall maintain sole responsibility for workers' health and safety including, but not necessarily limited to, interpreting monitoring or sampling results provided by the City or any another governmental agency, or performing Contractor's own monitoring or sampling to ensure worker health and safety.

8 – PROSECUTION AND PROGRESS

8.01 Subletting or Assigning of the Contract.

The Contractor shall obtain written permission from the City before subletting, selling, transferring, assigning, or disposing of any portion of the contract. The Contractor must perform a minimum of thirty (30) percent of the total contract sum unless otherwise specified. This limitation excludes any items designated as "specialty items" and the Contractor may subcontract such items. The Contractor is responsible for any subcontract or contract transfer under the contract and bonds. Subcontracting any portion of the work does not create any contractual relationship between the City and the Subcontractor. The City and representatives of the City shall possess the same power and authority over a Subcontractor as it possesses over a Contractor in accordance with the Contract Documents.

8.02 Determination of Contract Time Allowable for Completion of the Work.

The Contract Documents shall indicate a tentative date the Contractor may begin the work and the specific number of working or calendar days allowed for completing the work. The Engineer shall issue a Notice to Proceed indicating the starting date. The Contractor may request that the Engineer issue the Notice to Proceed before the tentative starting date indicated in the Contract Documents.

The Engineer is responsible for determining the days that constitute a working day. As required by the Contract Documents or the Engineer, work shall progress during the winter months. The computation of working days shall begin on the date established in the Notice to Proceed or in the Contract Documents. The Engineer shall compute working days until the work is complete unless the Engineer authorizes a temporary suspension of operations in accordance with Subsection 8.07. The Engineer shall count working days when suspending the work due to the Contractor failing to meet the requirements of the Contract Documents. The Engineer shall provide the Contractor periodic updates of the working days charged against the work. The Contractor shall have seven (7) days to appeal the working days charged. The Engineer shall resolve any disagreements. Failure to file written notification shall serve as evidence that the Engineer's records are accurate.

The Contractor is responsible for the timely delivery of materials from suppliers. The Contractor may request additional working days or a temporary suspension of the computation of working days to allow for material delivery. The Contractor shall make such requests in writing and shall include the reason for the delay and the anticipated delivery date. The Supplier must also supply a written statement verifying said reason and anticipated delivery date. The Engineer must approve any additional working days or temporary suspensions in accordance with the Contract

Documents. If, in the opinion of the Engineer, the reasons are not satisfactory, the Engineer shall not grant any additional working days or temporary suspensions.

The Contractor may request additional working days for excusable delays as defined in Subsection 1.03. Such request must be in writing, received within five (5) calendar days of the occurrence of the delay, and shall state the reason(s) for needing additional days. The Engineer may allow additional days if the Engineer agrees the delay is excusable. Shortage of labor is not an acceptable reason. The Engineer may allow additional working or calendar days to complete extra work if the Engineer feels that the extra work warrants such additions. The Engineer's decision is final and conclusive.

8.03 Prosecution of the Work.

Unless otherwise approved by the Engineer, the Contractor shall submit two (2) copies of a Contractor-prepared progress schedule to establish critical construction operations within seven (7) calendar days of receiving the fully executed contract. Unless otherwise approved by the Engineer, the progress schedule must be an Activities Schedule Chart (ASC) or Critical Path Method (CPM) Schedule. The Contractor shall ensure that the construction schedule meets specified overall Contract and milestone dates. The Contractor shall submit a revised schedule within fourteen (14) calendar days of receiving the Engineer's initial review comments. The Engineer's review comments are non-binding and do not constitute the Engineer's acceptance of any portion of the schedule. The Engineer and Contractor shall schedule periodic meetings to update the schedule throughout the progress of the work. When requested by the Engineer, the Contractor shall provide an updated schedule to reflect the portion of the work completed and any changes to the Contract Documents. Failure to provide a schedule as indicated will result in withholding all payments until the Contractor submits a schedule acceptable to the Engineer. The Contractor may pursue only minor work items such as ordering materials, preparing working drawings, and mobilization before submitting the schedule. The cost of preparing and maintaining the schedule is incidental to the contract items.

An ASC shall detail the duration of major construction activities for working day or completion date contracts and shall include Subcontractor, vendor, and supplier activities. The requirements of an ACS are as follows:

- Chronologically-sequenced bar chart showing a minimum of fifty (50) percent of the construction prosecution or preparation activities;
- Activity descriptions for each work category; and
- Activity duration by work day or calendar day.

A CPM Schedule shall plan and record project construction with a conventional CPM schedule using an activity on arrow diagram including Subcontractor, Vendor, and Supplier activities. The Contractor shall submit

either a hand-drawn or a computer-plotted activity on arrow diagram. The diagram network must be legible, readable, and easily understandable. The requirements of the CPM Schedule are as follows:

- Activity node.
- Activity description.
- Activity duration.
- Sequence and interdependence of all activities.
- Shop drawing submittals and approvals.
- Fabrication and delivery activities.
- Network "dummies."
- Trade or entity performing the work.
- Work force involved by trade, equipment, work location, and dollar value (base dollar value of each activity on the labor, materials, and equipment involved. Ensure that the total dollar value of all activities equals the Contract price).
- Work days each week, holidays, number of shifts per day, number of hours per shift.
- Major equipment for use on each activity.

For either an ASC or CPM Schedule, the Contractor shall note non-work intervals that exceed three (3) consecutive days or contract items that require more than twenty-one (21) working days.

8.04 Limitation of Operations.

The Contractor shall minimize interfering with traffic during performance of the work. The Contractor shall stage the work as required by the Contract Documents unless otherwise approved in writing by the Engineer.

8.05 Character of Workers.

The Contractor shall provide the resources necessary to complete the work as required by the Contract Documents. Workers must have the experience and skills to perform the work. The Contractor shall remove any employee(s) performing the work in an unskilled manner or behaving in an intemperate or disorderly manner. Such employees may return to the work only with the Engineer's written permission. The Engineer reserves the right to suspend work for failure to remove any employee(s) or to furnish suitable and sufficient personnel necessary to perform the work.

8.06 Contractor Methods and Equipment.

The Contractor shall use equipment of the size, capacity, and mechanical condition necessary to complete the work in accordance with the Contract Documents. Equipment shall not damage the adjacent property or other areas not adjacent to the project. The Contractor may request permission to use methods or equipment other than those required by the Contract Documents. Such request must be in writing and shall describe the

proposed methods and equipment and the reasons for the change. The Engineer reserves the right to allow only the methods or equipment required by the Contract Documents. The Contractor shall perform the work using alternate methods or equipment under the original basis of payment and contract time. The Contractor shall discontinue use of alternate methods or equipment when work does not meet the requirements of the Contract Documents. The Contractor shall remove and replace or repair such deficient work at no additional expense to the City.

The Contractor shall not construe the Engineer's approval of alternate methods or equipment as:

- Relieving the Contractor from furnishing other equipment or methods necessary to complete the work in accordance with the Contract Documents; or
- Binding the Engineer to accept work not complying with the Contract Documents.

8.07 Temporary Suspension of the Work.

The Engineer reserves the right to suspend all or a portion of the work due to the following:

- Conditions considered by the Engineer to be unfavorable to the proper prosecution of the work; or
- Failure of the Contractor to comply with the requirements of the Contract Documents.

The Engineer shall determine the limit of such suspension. The Contractor may not suspend the work without written authorization of the Engineer.

8.08 Progress of the Work.

The Contractor shall progress at a rate that will complete the work within the contract period. The Engineer reserves the right to order the Contractor to take steps deemed necessary to expedite the completion of the work if the Engineer believes that the work will not be completed within the contract period. Failure to make satisfactory steps may result in disqualification of the Contractor from submitting proposals for future work.

8.09 Liquidated Damages.

Specified liquidated damages will be deducted from progress payments or retainage for each working day or calendar day the contract remains incomplete after the contract period including approved time extensions. Work that continues after the specified contract period does not waive the City’s rights as defined by the Contract Documents. The Engineer reserves the right to suspend time charges on calendar day and working day contracts. The Contractor shall complete all remaining work with diligence.

The Engineer has sole authority to determine the dates upon which substantial completion and final completion have been achieved.

The Engineer shall assess liquidated damages based upon two (2) contract periods: days allowed for substantial completion and days allowed for final completion. Days allowed for substantial completion shall equal the contract period. Unless otherwise indicated in the Contract Documents, the days allowed for final completion shall equal an additional number of days, after substantial completion, equal to twenty (20) percent of the days allowed for substantial completion or twenty (20) working days, whichever is less. The Engineer shall round partial days up to the next whole day. The Contractor may not add any remaining days allowed for substantial completion to the days allowed for final completion or vice versa. Table 8.01 outlines the liquidated damages.

Table 8.01
Late Completion Penalties

	Damages per Day	
Amount of Contract	**Substantial Completion**	**Final Completion**
Less than $100,000	$150.00	$100.00
$100,000 to less than $250,000	$375.00	$250.00
$250,000 to less than $1,000,000	$1,500.00	$500.00
$1,000,000 to less than $5,000,000	$7,500.00	$500.00
$5,000,000 or greater	$15,000.00	$500.00

The Contractor shall not construe the assessment of liquidated damages as waiving the City's right to collect additional special damages sustained by the City due to Contractor failing to meet the requirements of the Contract Documents.

The Contractor shall submit a certified check to the City for the difference between any liquidated or additional damages and the contract retainage when such damages exceed the retainage. The Contractor must submit such check within thirty (30) calendar days of payment notice. If the Contractor fails to submit such check, the City may charge interest of the prime rate plus two (2) percent annual percentage rate compounded daily on the amount due the City.

8.10 Completion of Default Contracts.

The City may declare the contract in default if the Contractor:

- Fails to begin work in the time specified;
- Fails to perform the work with resources to ensure the prompt completion of the work;
- Fails to meet the requirements of the Contract Documents;
- Stops work;
- Fails to resume stopped work after receiving notice to proceed;

- Becomes insolvent or bankrupt, or commits related acts; is non-responsive to final third party judgments; or makes an assignment for the benefit of creditors;
- Fails to comply with minimum wage payments or EEO Contract requirements; or
- Is party to fraud.

The Engineer will notify the Contractor and the Surety in writing of conditions determined to be in default. Failure to correct such conditions within ten (10) calendar days after the Engineer has issued a written notice shall authorize the City to prosecute the work. The City may appropriate or use all materials and equipment at the project site and enter into an agreement for completing the Contract. The City may purchase from the Contractor, at actual cost, acceptable materials acquired for use on the project and not yet included in the work. The City will determine the method to complete the Contract. The City shall deduct all costs and charges incurred by the City, including the cost of completing the work under the Contract, from monies owed the Contractor. Should the expense exceed the sum that would have been payable under the Contract, the Contractor and Surety are liable for the difference. Damages to which a Contractor may be entitled following improper default termination are limited to the amounts specified.

8.11 Guarantee.

The Contractor shall guarantee seal coating, live plantings, seeding, and sodding for one (1) full year. All other work shall be guaranteed for two (2) full years. All guarantee periods shall commence on the date that the Engineer accepts the work. The Contractor shall maintain a guarantee bond during such period. The Contractor is responsible for all repairs or reconstruction necessary during such period due to any imperfection in the work. The Contractor agrees to commence any repairs or reconstruction within twenty (20) calendar days of receiving notice from the Engineer. Should the Contractor refuse or neglect to commence such repairs or reconstruction, the Engineer shall designate an individual or legal entity to perform such repairs or reconstruction. The Contractor or Surety(s) is responsible for the cost of such work.

The Contractor shall notify the Engineer in writing a minimum of thirty (30) days before the expiration of the guarantee period. The Engineer shall inspect the work and notify the Contractor of any areas requiring repair or reconstruction. Upon completion of such repair or reconstruction, the Engineer shall certify that the project is in good and proper condition and the guarantee shall expire on the appropriate date. If any repair or reconstruction remains incomplete at the end of the guarantee, the Contractor shall extend the guarantee until such work is completed.

8.12 Termination of the Work.

The City may stop the contract in whole or in part for any of the following reasons:

- Executive Orders of the President or State Governor.
- Court restraining orders based on acts or omissions of persons or agencies associated with the Work other than the Contractor.
- Conditions determined to be in the best interest of the City.

Termination of the contract for such reasons shall not relieve the Contractor or Surety of responsibility for or any just claim arising due to the work performed. The City shall provide a written notice detailing the effective date and specifics of the termination. Upon receipt of such notice, the Contractor shall immediately:

- Stop work as specified.
- Place no further subcontracts or order materials, services, or facilities, except as approved to complete any remaining portion of the Contract.
- End all subcontracts to the extent they relate to canceled work.
- Settle all outstanding liabilities and termination settlement proposals.
- Transfer title and deliver to the City any unfabricated or partially fabricated parts, work in process, completed work, supplies, and other material produced or acquired for the work terminated.
- Furnish the City any completed or partially completed plans, drawings, information, and other property required as if the Contract were completed.
- Complete work not terminated.
- Coordinate with the Engineer to inventory materials obtained but not used for the project.
- Take all necessary or directed action to protect Contract-related property of which the City has or may have an interest.

The City shall pay the Contractor for all items of the work completed at the contract price. The City shall pay the Contractor for items of work partially completed at a mutually agreed price. The City shall purchase all acceptable materials not incorporated into the work, but obtained or ordered by the Contractor, at the actual cost as indicated by receipts or other verified cost records. The City shall reimburse the Contractor for overhead expenses related to the termination of the contract as extra work. The City will not consider any claims for loss of anticipated profits.

8.13 Incentive for Early Completion.

If specified in the Contract Documents, the Contractor may earn incentive payment for completing the work or a specified portion of the work before the specified completion time established by the Contract Documents. The Engineer shall determine when the Contractor meets such requirements.

THIS PAGE LEFT INTENTIONALLY BLANK

9 – MEASUREMENT AND PAYMENT

9.01 Measurement of Quantities.

Upon completion of the work, the Engineer shall measure and compute the final quantities of the work. Unless otherwise indicated in the Contract Documents, the City shall pay the Contractor only for the actual quantity of work performed. The Engineer shall use field-verified final quantities for the final payment. The Engineer shall use the units of measure specified in the Contract Documents to measure completed work. The Engineer shall measure materials at the point of delivery. The Engineer shall determine any necessary conversion factors. The Engineer shall accept material and work measurements and computations conforming to sound engineering practice.

The Engineer shall use the average-end-area method to compute removal, construction, excavation, and embankment volumes.

The Engineer shall use certified, permanently installed commercial scales or other weigh systems tested and certified by an individual or legal entity acceptable to the Engineer to determine the quantity of materials accepted by weight. A ticket generated from an automatic printout device must indicate the weight of the material. The Contractor shall furnish certified transport vehicle weights as required by the Engineer. The Contractor shall ensure that each transport vehicle displays a legible identification mark. The Contractor shall provide proof of scale certification as requested by the Engineer. The weigh system shall display a certification stamp verifying accuracy to within 0.05 percent.

9.02 Scope of Payment.

Payment of the Contract unit price is full compensation for all resources necessary to complete the item of work as defined in the Contract Documents. The Contractor assumes liability for any risk, loss, damage, or expense resulting from the prosecution of the work unless otherwise indicated in the Contract Documents.

9.03 Compensation for Altered Quantities.

The Contractor shall accept payment for work quantities that vary from Contract quantities at the original Contract Prices in accordance with Subsection 4.02. The City shall not make any allowances or adjustments due to increased expense, loss of expected reimbursement, or loss of anticipated profits resulting from alteration of the work or unbalanced bidding.

9.04 Differing Site Conditions, Changes, Extra Work, and Force Account Work.

The Contractor shall accept payment for work outlined in the Contract Documents by contract unit prices, mutually agreeable unit prices, mutually agreeable lump sum, or on a force account basis. The Contractor must notify that Engineer immediately upon discovering any differing site condition that will cause the Contractor any additional expense, damage, or effort that the Contractor will claim any additional compensation. The Contractor shall make such notice in writing within twenty-four (24) hours thereafter. The Engineer and the Contractor must agree, in writing, upon the method of payment before starting such work due to such site conditions. The Engineer shall notify the Contractor, as soon as possible if, and to what extent, there will be compensation for such expenses not treated as extra work. The Contractor must notify the Engineer before commencing any work that the Contractor may claim as extra work to allow the Engineer to account for the actual costs of performing such work. If the Contractor fails to provide the Engineer such notice, the Contractor agrees to waive any claim for additional compensation. The Contractor shall not construe any documentation by the Engineer as validating a claim for additional compensation. The Engineer shall decide the validity of a claim.

The City shall compensate the Contractor for force account work as follows:

Labor: The actual time and wages of workers and supervisors directly performing the approved extra work. The Engineer must approve the wages in writing before beginning work. The City will not compensate the Contractor for the time and wages incurred by general superintendence or other workers not directly performing such extra work. The wages shall include the actual costs paid for, subsistence and travel allowances, health and welfare benefits, pension fund benefits, or other benefits required by a collective bargaining agreement or other employment contract applicable to the class of labor employed. The Contractor may add an additional fifteen (15) percent of the above sum for project overhead and profit.

Bond, Insurance, and Tax: The City shall reimburse the actual cost, plus five (5) percent, for property damage, liability, and Workers Compensation insurance premiums, unemployment insurance contributions, and social security taxes. The Contractor shall furnish evidence of the rate(s) paid.

Materials Costs: The City shall reimburse the actual invoiced delivery costs plus five (5) percent.

Equipment: The City shall calculate compensation for Contractor-owned machinery or other approved special equipment other than small tools using the hourly rates from the latest edition of "The Rental Rate

Blue Book for Construction Equipment" as published by Dataquest. Apply rental rates identified in the guide as follows:

- Use hourly rates, determined by dividing the monthly rate by 176.
- Base payment on the number of hours that the equipment or plant is actually used.
- Use the rates in effect on the first day that the extra work began.
- Do not apply an area adjustment. Use rate adjustment tables to correct for equipment life.
- Base overtime calculations on item a. above.
- Include estimated operating costs for each hour the equipment or plant is in actual operation. Do not include idle time, regardless of cause, except as provided for in item g.
- Pay for equipment idle time held on the project on a standby basis at one-half the rate established in item a. above. Do not calculate standby time on a day that the equipment operates for eight (8) or more hours. Limit standby hours and normal operating hours to 8 in any work day. Pay standby only for normal workdays.
- Calculate the transportation costs for moving the equipment or plant to or from the site.
- Include the cost of all incidentals in the rates established above.

The Contractor shall obtain the Engineer's approval for rates exceeding those outlined in items a through i. The City shall not compensate the Contractor for time lost due to equipment breakdown and repair. The City shall compensate the Contractor for equipment up to twenty-four (24) hours after such equipment becomes unnecessary. The Contractor shall obtain a written agreement with the Engineer to use equipment not included in the rental rate guide.

These provisions apply only to equipment owned directly by the Contractor or by entities associated with the Contractor or its parent company. The Contractor shall obtain the Engineer's approval for the use of and rate for rental equipment. The City shall base rental equipment reimbursement on the actual paid invoice for the equipment. The City shall reimburse the Contractor for transportation charges to and from the work site if the following is correct:

- Equipment is obtained from the nearest approved source,
- Return charges do not exceed delivery charges,
- Haul rates do not exceed established rates of licensed haulers, and
- Equipment units are unavailable on or near the project.

The Contractor shall submit invoices for all charges by individuals or firms other than the Contractor.

Subcontracting: The City shall reimburse the Contractor for the approved Subcontractor invoice plus five (5) percent.

Cost Records: The Contractor shall obtain the Engineer's daily approval of cost records.

Statements: The Contractor shall furnish a weekly, itemized cost statement to the Engineer detailing the following:

- Name, classification, date, daily hours, total hours, rate, and extension for each laborer and foreman.
- Designation, dates, daily hours, total hours, rental rate, and extension for each unit of equipment.
- Quantities of materials, prices, and extension.
- Materials transportation costs.
- Property damage, liability, and workers compensation insurance premiums, unemployment insurance contributions, and social security costs.

The Contractor shall support statements with accompanying certified payrolls and invoices for all materials used and transportation charges. The Contractor shall furnish an affidavit for materials taken from the Contractor's stock and not specifically purchased for the work. The affidavit shall certify the origin, quantity used, price, and transportation cost. The Contractor shall accept the total payment as provided for above as full compensation for the work.

9.05 Eliminated Items.

The Engineer reserves the right to eliminate contract items. The Contractor may request reimbursement for all tangible costs incurred before notification of elimination. The Engineer shall decide the validity of any such request.

9.06 Progress Payments.

The City may issue monthly progress payments based on the estimated value of completed work and materials delivered in accordance with the Contract Documents. The City shall retain ten (10) percent of the estimated amount until the Engineer determines the work to be substantially complete. After such time, the City shall retain a minimum of five (5) percent of the estimated amount until issuing final payment. At no time shall the amount of the retainage be less than the estimated amount of any late completion penalties or other damages or debits. The City shall pay the retainage upon acceptance of the work and receipt of all required submittals. The City may reduce the amount retained at the discretion of the Engineer.

The City shall limit progress payments to the appropriate value of the contract price. The Contractor shall provide copies of paid invoices within thirty (30) days of receipt of progress payment. The Contractor

acknowledges that approval of progress payment for stockpiled materials is not final acceptance of the materials. The Contractor is responsible for any damage to or loss of material until the Engineer accepts such material after incorporation into the work.

The City will not issue progress payments for any questionable or defective work or living or perishable plant materials until planted. Progress payments shall not include any materials that will not become an integral part of the finished work. The City reserves the right to correct any errors in previous progress estimates when issuing future progress payments or final payment.

After the Engineer accepts the work, the Contractor shall submit evidence, satisfactory to the Engineer, of compliance with the provisions of Paragraph 4 of Section 48-657 R.R.S. Nebraska 1943. The City shall retain any monies earned if the Contractor or Subcontractor fails to keep the required insurance coverage in effect or fails to submit the required documentation during prosecution of the work.

9.07 Stored Materials.

The City may issue progress payment for materials designated for incorporation into the work that:

- Meet Contract Document requirements;
- Are purchased expressly to be incorporated into the work;
- Are delivered and stockpiled at the project site or other approved location;
- Are to be stockpiled more than 90 days;
- Have a per unit cost greater than one hundred ($100.00);
- Are supported by copies of paid invoices or receipt of delivery; and
- Are not living or perishable.

The City shall reimburse the Contractor for materials received and verified. The reimbursement value shall be one hundred (100) percent of the cost less the retainage amount as defined by the Contract Documents. The reimbursement value may not exceed the appropriate portion of the value of the contract item(s) in which incorporate such materials. The quantity of stored materials eligible for reimbursement shall not exceed the total estimated quantity required to complete the work. The City shall deduct any progress payments for eligible materials from progress payments for completion of the contract item(s) in which incorporate such materials.

Payment for eligible materials shall not constitute acceptance of the materials. The Contractor is responsible for any damages to or loss of stored materials until such materials are incorporated and accepted. The City shall reimburse the Contractor for all other items upon completion and acceptance of the work.

9.08 Acceptance and Final Payment.

After performing a final inspection, the Engineer shall issue a statement indicating that the Engineer has tentatively accepted the work. The statement shall indicate that the Contractor is relieved of any further public liability upon removal of any equipment or excess materials from public right-of-way. The Engineer may tentatively accept portions of the work without voiding or altering any terms of the Contract.

The City shall issue final payment based upon the quantities of accepted work as determined by the Engineer. The Contractor may file a formal objection to the quantities within thirty (30) calendar days of acceptance of the work. Objections must be in writing and provide sufficient detail to permit final adjudication. The Engineer shall resolve any discrepancy and such decision is final. The City shall issue final payment when the Engineer is satisfied that all work conforms to the Contract Documents, all final quantities are agreed upon, and all necessary submittals have been received and accepted. Final payment shall reflect the entire sum due minus any previous progress payments, deductions, and corrections.

10 – WAGES AND CONDITIONS OF EMPLOYMENT

10.01 Scope.

All provisions pertaining to wages and conditions of employment shall apply to all workers of the Contractor or Subcontractor(s) performing work under the contract. Failure to comply with such provisions is a breach of the contract.

10.02 Labor Laws.

The Contractor shall not discriminate against any person or recipient of services because of race, color, sex, religion, creed, age, marital status, physical or mental disability, political opinions or affiliation, or national origin or ancestry. The Contractor shall comply with the Nebraska Fair Employment Practices Law and with all requirements of the Employment provisions of the Omaha Municipal Code.

The Contractor shall comply with the provisions and requirements of the State Workmen's Compensation Law and with any Statutes regulating the conditions of employment on public work. The City reserves the right to impose additional regulations or restrictions as defined by the Contract Documents. The Contractor and any Subcontractor(s) shall comply with the City of Omaha Affirmative Action Program. The Contractor shall supply evidence acceptable to the Engineer of such compliance.

The Contractor is responsible for providing acceptable working conditions in accordance with the current version of Title 29, Code of Federal Regulations, Part 1926 (formerly Part 1518) as authorized by the US Secretary of Labor, in accordance with Section 107 of the Contract Work Hours and Safety Standards Act (83 Statue 96).

10.03 Employment of Labor.

All workers must be a minimum of sixteen (16) years of age and a US citizen or legal resident alien. The Contractor or Subcontractor(s) shall not employ a worker whose physical condition endangers the health or safety of the worker or other workers employed on the project. The Contractor may assign employable, physically handicapped persons such duties that the person can safely and ably perform. The Contractor shall notify the Engineer, in writing, of any person currently serving a sentence to a penal or correction institution and employed on the project.

THIS PAGE INTENTIONALLY LEFT BLANK

100 SITE PREPARATION

101 – CLEARING AND GRUBBING

101.01 Description.

This work shall consist of clearing the right-of-way to the extent necessary for the construction of the project. Remove and dispose of all stumps, dead trees, logs, down timber, brush, other herbaceous vegetation, rubbish or trash, and unwanted materials from within the limits of the right-of-way to the extent necessary to perform the work. Do not remove live trees, hedge, shrubs, or grass beyond the limits of construction, except as indicated in the Contract Documents or designated by the Engineer. Perform work within the right-of-way and outside the limits of construction in a manner that precludes injury or damage to live trees.

General clearing and grubbing shall consist of the removal and disposal of wire and/or board fences, all trees with diameters of nine (9) inches or less and stumps with diameters of twelve (12) inches or less, and will include the removal and disposal of all other objectionable material such as logs and down timber, shrubs, hedges, brush, weeds, grass, other herbaceous vegetation, and rubbish or trash encountered within the limits of the right-of-way, other areas indicated in the Contract Documents or designated by the Engineer. All living trees or shrubs located within the right-of-way but not within the limits of construction shall not be removed, injured or destroyed, except as otherwise indicated in the Contract Documents or designated by the Engineer.

Clearing and grubbing trees will consist of the removal and disposal of trees over nine (9) inches in diameter, the stumps of such trees and the large roots.

Grubbing stumps will consist of the removal and disposal of stumps over twelve (12) inches in diameter and the large roots of such stumps, where others not party to the Contract removed the tree.

101.02 Material Requirements.

None.

101.03 Construction Requirements.

(A) Object Removal.
Remove and dispose of all surface objects, vegetation, trees, stumps, roots, and other designated obstructions to a minimum depth of one (1) foot below finished grade elevation. Use of an approved mechanical stump chipper is acceptable but not required for accomplishing stump removal. Removal of stumps greater than three (3) feet below finished grade in embankment areas is not required. Cut such stumps flush or

below the existing ground. Disregard any stumps or nonperishable solid objects that extend less than three (3) inches above the ground line or low water level when they are outside excavation and embankment areas.

Backfill any holes remaining after the removal of the obstruction except in excavation areas using suitable materials compacted to a minimum of ninety-two (92) percent of the maximum density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

(B) Object Preservation.

Preserve trees, shrubs, plants, and other objects that are to remain within established limits as directed by the Engineer or indicated in the Contract Documents. Remove low-hanging and unsound branches from remaining trees or shrubs using proper tree surgery practices to trim tree branches. Trim branches of trees extending over the roadbed to provide a clear height of at least fifteen (15) feet. Treat cut or scarred tree or shrub surfaces with an asphaltum-based paint manufactured for tree surgery.

A certified Forester shall supervise all tree and root trimming operations.

(C) Object Disposal.

Dispose of all material resulting from clearing and grubbing work in a manner acceptable to the Engineer, in conformance with the Contract Documents, and in accordance with all local, State and Federal regulations. The Engineer shall resolve any conflicts. The City reserves the right to retain ownership of any materials designated for disposal. Dispose of materials that the City retains ownership of at a location designated by the Contract Documents or the Engineer. Obtain all necessary written arrangements with property owners and governmental authorities for disposal locations outside the Right-of-Way limits. The Contractor may enter agreements with persons or legal entities regarding the disposal of any material resulting from clearing and grubbing work. All such agreements shall remain separate of the Contract and shall not relieve the Contractor of any responsibility to comply with the Contract Documents.

Bury disposable material and debris at designated locations with at least two (2) feet of cover material. If the Contract Documents do not designate a location(s), dispose of such material at a location(s) outside the Right-of-Way. Do not pile any materials within the right-of-way of any alley, street, drive, road, walkway, drainage way, or any other public property or the flood plain of any channel unless otherwise allowed by the Contract Documents or authorized in writing by the Engineer.

(D) Mowing

Mow worthless vegetation with a height of eighteen (18) inches or greater as close to the ground as possible in accordance with all applicable local, State and Federal regulations or as directed by the Engineer. The Engineer shall approve of the equipment and methods used for mowing.

101.04 Measurement and Payment.

The Engineer shall measure general clearing and grubbing as on a lump sum basis.

The Engineer shall measure the clearing and grubbing of trees as a single unit defined as the number of trees within a defined diameter range removed and accepted. Determine the diameter by measuring the circumference two (2) feet above the surrounding ground and dividing this circumference by 3.14.

The Engineer shall measure the grubbing of stumps as a single unit defined as the number of stumps within a defined diameter range removed and accepted. Determine the diameter by measuring the circumference at the cutoff elevation and dividing by 3.14.

The Engineer shall measure separately the trimming of tree branches as a single unit defined as the number of labor-hours excluding the first two (2) hours per tree of tree branch trimming performed and accepted.

The Engineer shall measure separately the trimming of tree roots as a single unit defined as the number of labor-hours excluding the first two (2) hours per tree of tree root trimming performed and accepted.

Mowing is subsidiary to items for which the Contract provides direct payment.

Tree and root trimming to obtain the necessary clearances that requires less than two (2) labor-hours per tree is subsidiary to items that the Contract provides direct payment.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for removal and disposal of vegetation, trees, stumps, and all other objectionable or unwanted material, backfilling, and for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Clearing and Grubbing – General	Lump Sum
Clearing and Grubbing Trees Over __ to __ Diameter	Each
Clearing and Grubbing Trees Over __ Diameter	Each
Grubbing Stumps Over __ to __ Diameter	Each
Grubbing Stumps Over __ Diameter	Each
Tree Branch Trimming	Labor-Hours
Tree Root Trimming	Labor-Hours

102 – STRUCTURES AND OBSTRUCTIONS REMOVAL

102.01 Description.

This work includes removing, salvaging, backfilling, and disposing of buildings, guardrail, retaining walls, fences, junction boxes, headwalls, culverts, bridges, structures, and PCC, brick, stone block, and ACP paved walkways and steps and clearing of tracts as indicated in the Contract Documents or directed by the Engineer.

102.02 Material Requirements.

Unless otherwise indicated in the Contract Documents, backfill materials shall consist of silty clay (CL-ML) or lean clay (CL) materials as determined in accordance with ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes. Backfill materials shall be free of debris, vegetation, or organic matter. The Engineer must approve all borrow material in writing before use by the Contractor.

102.03 Construction Requirements.

Excavate as necessary to accomplish the required removals. If portions of structures are to remain in place, the Contractor shall saw cut a true line to separate the portions.

Remove, salvage, or dispose of structure(s) or obstruction(s) to the horizontal limits and a minimum depth of six (6) inches below the surrounding ground or final elevation in excavation areas as indicated in the Contract Documents or as directed by the Engineer. Reface the discontinued end of an existing retaining wall left in place to match the original construction as nearly as possible and the satisfaction of the Engineer. Demolish all bridge trusses deemed unfit for reuse on public roadways in a manner that prohibits re-assembly or re-use.

Remove only the portions indicated in the Contract Documents or those that interfere with the new construction when the Contract Documents provide for using any part of an existing structure in a new structure. Cut or chip and trim the connecting edges of the existing structure to the required lines and grades, without weakening or damaging that part of the retained structure.

Accomplish clearing of tracts by removing all foundations, basement walls, driveways, walks, and other miscellaneous items encountered within the limits of the specific tract involved and disposing of all materials encountered in the work. Remove basement walls and all other miscellaneous removals encountered to a minimum depth of three (3) feet below finished ground elevation.

Disconnect all sewer and utilities encountered. Plug sewer service lines at the property line in a manner acceptable to the Engineer. Remove all sewer service lines between the structure and the property line. Shut-off water service valves at the water main before abandoning. Contact the Metropolitan Utilities District to arrange for the gas service to be shut-off.

Remove all bridges, culverts, or other drainage structures within the channel to the natural channel bottom or as directed by the Engineer. Remove portions of the drainage structure located outside the natural channel bottom to one (1) foot below the surface of the surrounding ground. Completely remove all steel and timber superstructures, substructures, and the top slabs and decks of all abandoned PCC and masonry bridges and culverts. Remove PCC and masonry abutments and walls to a minimum of two (2) feet below the subgrade, surface of slopes, or ground level. Remove piers to the elevation of the streambed. Cut or drive piles two (2) feet below the finished surface in all areas except running streams. Cut piles to the elevation of the streambed in all running streams.

Dismantle and store salvaged materials without damage. Match-mark all individual pieces of the salvaged materials and transport them to the designated location(s). Do not cut, bend, or otherwise damage materials salvaged for the City. Salvage any culvert pipe removed and not reused. Clean such pipe to remove accumulations of dirt and debris. Deliver such pipe to a designated City-owned facility unless otherwise directed by the Engineer. Store salvaged materials at the location(s) designated by the Contract Documents or as directed by the Engineer. Keep stored materials free from contamination by dirt or other foreign matter.

Do not use concrete or masonry rubble at the toe of slopes or berms, around new piers or culverts, as a stream bank anchor, or as rip rap without written approval from the Engineer. Process all materials broken for use as rip rap to sizes less than one hundred fifty (150) pounds.

All excess materials removed from the project site(s) shall be disposed of at locations acceptable to the City of Omaha. The Contractor shall identify in writing the location(s) of his disposal site and provide this to the Engineer at the pre-construction meeting. During the project construction, the Contractor shall keep the Engineer informed of all disposal dates, locations, and approximate material quantity.

Dispose of non-salvaged materials in a manner acceptable to the Engineer, in conformance with the Contract Documents, and in accordance with all local, State, and Federal regulations. Obtain all necessary written arrangements with property owners and governmental authorities for disposal locations outside the Right-of-Way limits. The Contractor may enter into agreements with persons regarding the disposal of any material. All such agreements shall remain separate of the Contract and shall not

relieve the Contractor of any responsibility to comply with the Contract Documents.

Bury disposable material and debris at designated locations with at least two (2) feet of cover material. If the Contract Documents do not designate a location(s), dispose of such material at a location(s) outside the Right-of-Way. Do not pile materials within the Right-of-Way of alleys, streets, drives, roads, walkways, drainage ways, or any other public property or the flood plain or stream channel unless otherwise allowed by the Contract Documents or authorized in writing by the Engineer. Do not use broken PCC or masonry rubble at the toe of slope and berms, around new piers and culverts, and as stream bank anchor or rip rap only as directed by the Engineer. Unless otherwise provided, the unit price bid for the removal of existing structures will include all right and title to the structure removed.

Backfill using materials acceptable to the Engineer. Provide borrow material unless otherwise directed by the Contract Documents. The Contractor may use suitable and available excavation materials before using borrow excavation. The Engineer must approve of all off-site borrow materials before use. The Contractor is responsible for obtaining a sufficient amount of borrow material.

The Contractor may place rocks, broken concrete, or other solid materials less than six (6) inches in size in backfill areas other than those designated for placing or driving piling as allowed by the Engineer. Cover rocks, broken PCC, or other solid materials with at least two (2) feet of embankment material.

Place backfill materials in uniform horizontal layers not exceeding eight (8) inches loose lift thickness. Construct each layer of the backfill material to the specified density before placing additional layer. Adjust the moisture content as necessary to fulfill moisture requirements. The Engineer reserves the right to alter the thickness of the lifts to meet the specific conditions of the project site. Place successive lifts in a manner that does not significantly alter the moisture content or density of previously completed lifts. Construct the first layers of backfill materials over soft, saturated ground using light, tracked equipment and lift thickness acceptable to the Engineer.

Compact the backfill material uniformly to produce a surface that does not yield under repeated loading by heavy trucks or equipment. Construct the backfill to meet the requirements of Table 102.01. The maximum dry density (Standard Effort) and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). The maximum dry density (Modified Effort) and optimum moisture shall be determined by ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

Table 102.01
Backfill Requirements

Depth Below Pavement or Finished Grade	Minimum Compaction Requirement	Acceptable Moisture Range
≤ 1 foot (under pavement and within 4 feet of the edge of pavement and under sidewalk/ bike trail)	90% of Maximum Dry Density (**Modified** Effort)	Optimum Moisture Content –3%, +4%
≤ 1 foot (beyond 4 ft of pavement or beyond edge of sidewalk / bike trail)	92% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%
Greater than 1 foot (all locations)	95% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%

Step the sides of existing natural or backfill slopes steeper than 1V:3H. The vertical depth of the step shall be less than one (1) foot and the vertical face shall be no steeper than 1V:1H. The base of the step shall be nearly horizontal. Extend the face horizontally into the existing natural or embankment slope until encountering stable soils. Horizontal cuts shall begin at the intersection of the ground line and the vertical side of the previous bench. Compact the materials excavated as part of stepping operations with the new embankment material as allowed by the Engineer.

When backfilling along a structure, compact backfill materials without applying excessive pressure against the structure. Grade embankment surfaces to be smooth and uniform. The final elevation of the embankment shall be within one-half (½) inch of the design elevation.

The City reserves the right to sell and remove buildings from tracts before the commencement of work. If buildings are sold and removed from the tract before this date, the City reserves the right to delete the bid item for removing the building and replace it with a bid item for the clearing of the tract. The City reserves the right to salvage valuable or reusable items such as doors, windows, and fixtures from buildings before the commencement of work.

102.04 Measurement and Payment.

The Engineer shall measure the removal of structures or obstructions as single units defined by the structure or obstruction units indicated below removed, salvaged or disposed of, and accepted. The City salvaging valuable or reusable items shall not delete the bid item for removing the building. Perform the remaining work under the bid item for building removal at no change in contract unit price.

The Engineer shall measure clearing of tracts on a lump sum basis.

The Engineer shall measure salvaging of pipe as a single unit defined by the number of linear feet, regardless of diameter, removed, salvaged, cleaned, delivered, and accepted.

The Engineer shall measure removal of guardrail as a single unit defined by the number of linear feet or guardrail removed, salvaged, cleaned, delivered, and accepted. The Engineer shall conduct measurements from center to center of end posts and shall not include the distance of the section of beam element or terminal section projecting beyond these points. Removal of such projections is subsidiary to items for which the Contract provides direct payment.

Excavation for removals is subsidiary to items for which the Contract provides direct payment. Removal of other walkway surfacing other than PCC, brick, stone block, and ACP is subsidiary to items for which the Contract provides direct payment. Backfilling of any cavities created by the removal of a structure or obstruction is subsidiary to items for which the Contract provides direct payment.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. Unless otherwise indicated in the Contract Documents, the Contract Price shall include all right and title to the structures or obstructions removed. The Contract Price shall be full compensation for removing, salvaging, storing, and disposing of buildings, culverts, bridges, headwalls, endwalls, pipe culvert, pipearch culvert, guardrail, surplus material, and all miscellaneous material encountered; excavation; backfilling; and for all labor, equipment, tools and incidentals required to complete the work.

Description	**Unit**
Clear Tract	Lump Sum
Remove __ or Smaller Sewer Pipe	Linear Foot
Remove __ to __ Sewer Pipe	Linear Foot
Remove __ Sewer Pipe	Linear Foot
Remove __ or Smaller culvert Pipe	Linear Foot
Remove Culvert Pipe Over __ to __	Linear Foot
Remove __ Culvert Pipe	Linear Foot
Remove Manhole	Each
Remove Inlet	Each
Remove Curb Inlet	Each
Remove Area Inlet	Each
Remove Flared End Section (less than __)	Each
Remove Flared End Section (__ to __)	Each
Remove Flared End Section over __ to __	Each
Remove Headwall	Each
Remove Pipe Support	Each
Remove Abandoned C.I. Main	Linear Foot
Remove Steps	Each
Remove Concrete Retaining Wall	Square Foot
Remove Rip-Rap Retaining Wall	Square Foot
Remove Railroad Track	Linear Foot
Remove Street Car Track	Linear Foot
Remove Building	Each
Remove Fence	Linear Foot

.

103 – SEWER ABANDONMENT

103.01 Description.

This work includes abandonment of existing manholes, catch basins, inlets, discharge structures, or drainage pipe. Abandonment includes removing the cover and top, breaking down the walls to an elevation a minimum of three (3) feet below the surrounding ground or finished grade elevation, plugging all sewer openings with an acceptable plug, breaking up the floor of the structure into pieces, and filling the opening.

103.02 Material Requirements.

(A) Brick.
Brick shall conform to the requirements of ASTM C62, Standard Specification for Building Brick (Solid Masonry Units Made From Clay or Shale) or ASTM C32, Standard Specification for Sewer and Manhole Brick (Made From Clay or Shale).

(B) Concrete Block.
Concrete block shall conform to the requirements of ASTM C139, Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes.

(C) Mortar.
Mortar shall conform to the requirements for Mortar Type M or Type S as defined by ASTM C270, Standard Specification for Mortar for Unit Masonry.

(D) Sand Gravel Fill.
Sand gravel shall consist of a well-graded sand gravel.

(E) Portland Cement for PCC, Low Strength Concrete, and Flowable Fill.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2, and Table 4.

(F) Aggregate for PCC, Low Strength Concrete, and Flowable Fill.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(G) Fly Ash for Flowable Fill.
Fly ash shall conform to the requirements of Class C Fly Ash as defined by ASTM C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.

(H) Water for PCC, Low Strength Concrete, and Flowable Fill.
All water used in the concrete mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(I) Admixtures for PCC, LSC, and Flowable Fill.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete, ASTM C1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete, or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. An accredited laboratory shall certify that the admixture meets the requirements of the appropriate ASTM designation. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Add calcium chloride on the project site. Mix the calcium chloride in a minimal amount of water before adding to the concrete. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the concrete. Do not use calcium chloride in colored concrete.

Do not use any admixtures that retard the initial set of the concrete without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(J) Flowable Fill Mix Proportioning and Required Properties.
Prepare and submit a flowable fill mix design that identifies the component materials, the proportion of such materials, the twenty-eight (28) day compressive strength, and the air content. Flowable fill shall have a twenty-eight (28) day compressive strength of 75±50 psi and an air content of 10±3%. Proportion the materials to produce a mixture with a consistency that flows under a very low head.

(K) Fly Ash Slurry Mix Proportioning and Required Properties.

Fly ash shall conform to the requirements for Class C Fly Ash of ASTM C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.

All water used in the slurry mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete Standard Specification for Water Used in Concrete. Obtain such water from a source approved by the Engineer.

Proportion the fly ash and water to produce a flowable slurry that yields a compressive strength of one hundred (100) psi or greater in seven (7) days.

(L) LSC Mix Proportioning and Required Properties.

Proportion LSC mixtures to meet the requirements of Table 504.01. Do not use fly ash in the low strength concrete mix. Add the air-entraining admixture in a manner that will ensure uniform distribution of the agent throughout the batch. The Contractor shall base the air content of freshly mixed air-entrained low strength concrete upon trial mixes with the materials to be used in the work adjusted to produce a mixture of the required plasticity and workability.

Table 504.01
LSC Properties

Property	Requirement
Portland Cement Content, lbs. per cubic yard	200 min.
Coarse Aggregate, % of Total Aggregate	0
Fine Aggregate, % of Total Aggregate	100
Maximum Water Cement Ratio	0.45
Minimum 28-Day Compressive Strength, psi	1500
Entrained Air Content, %	8.0±2.0
Slump, inches	2.0±1.0
Maximum Freeze-Thaw Loss, %	14
Low strength concrete Temperature during placement, (°F)	70±25

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM D560, Standard Test Methods for Freezing and Thawing Compacted Soil-Cement Mixtures
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(M) PCC Mix Proportioning and Required Properties.

Proportion PCC mixtures to meet the requirements of Table 503.01. Do not use fly ash in the PCC mixture.

Table 503.01
Concrete Properties

Mix Type	SG65	L6
Portland Cement Content, lbs. per cubic yard	611 min.	564 min.
Coarse Aggregate, % of Total Aggregate	0	30±3
Fine Aggregate, % of Total Aggregate	100	70±3
Maximum Water Cement Ratio	0.45	0.45
Minimum 28-Day Compressive Strength, psi	3500	3500
Entrained Air Content, %	6.5±1.0	6.5±1.0
Slump, inches	2.5±1.5	2.5±1.5
Concrete Temperature during placement, °F	70±20	70±20

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

103.03 Construction Requirements.

(A) Sewer Preparation.

Excavate as necessary to expose the necessary portions of the abandoned sewer.

Preserve or rebuild any sewer pipes connected to abandon sewer lines when the Contract Documents require adding extensions to such pipes. Plug the open end and the discharge end when abandoning existing pipe. Remove the upper portion of abandon manholes to a minimum of three (3) feet below the finished elevation of the surrounding ground. Remove all rubble and debris from the remaining portion of the manhole. Backfill abandon manholes as required by the Contract Documents or as directed by the Engineer.

Dismantle and store salvaged materials without damage. Salvage any culvert pipe removed and not reused. Clean such pipe to remove accumulations of dirt and debris. Deliver such pipe to a designated City-owned facility unless otherwise directed by the Engineer. Store salvaged materials at the location(s) designated by the Contract Documents or as directed by the Engineer. Keep stored materials free from contamination by dirt or other foreign matter.

Dispose of non-salvaged materials in a manner acceptable to the Engineer, in conformance with the Contract Documents, and in accordance with all local, State, and Federal regulations. The Engineer shall resolve any conflicts. Obtain all necessary written arrangements with property owners and governmental authorities for disposal locations outside the Right-of-Way limits. The Contractor may enter agreements with persons regarding the disposal of any material. All such agreements shall remain separate of the Contract and shall not relieve the Contractor of any responsibility to comply with the Contract Documents.

Bury disposable material and debris at designated locations with at least two (2) feet of cover material. If the Contract Documents do not designate a location(s), dispose of such material at a location(s) outside the Right-of-Way. Do not pile materials within the Right-of-Way of alleys, streets, drives, roads, walkways, drainage ways, or any other public property or the flood plain or stream channel unless otherwise allowed by the Contract Documents or authorized in writing by the Engineer.

(B) Pipe Plug.

Construct a pipe plug consisting of brick or concrete block evenly spaced and secured using mortar at the outlet end of the abandoned structure in accordance with the Contract Documents. Fill in the structure starting at the outlet end using the fill material identified in the Contract Documents. The Contractor may construct a partial depth pipe plug on the inlet end of the abandoned structure to facilitate placement of the fill material. Upon completion of the fill material placement, the Contractor shall construct or complete the pipe plug for the inlet end of the structure.

(C) Fill Material.

Place the fill material in a manner acceptable to the Engineer. Consolidate all fill material to eliminate voids using vibratory equipment or other methods acceptable to the Engineer.

(D) Flowable Fill.

The National Ready Mixed Concrete Association must certify the flowable fill production facility. Mixing times shall conform to the requirements of ASTM C94, Specification for Ready-Mixed Concrete. Hand mixing is unacceptable. The production facility shall supply a load ticket with the actual batch weights of component materials.

Thoroughly mix all water added at the project site in accordance with the recommendations stated in ACI 305, Hot Weather Concreting. Measure all water added to the mix. Do not exceed the water cement ratio stated in the flowable fill mix design approved by the Engineer. Do not add water after discharge of the flowable fill from the mixer has begun.

Place flowable fill within ninety (90) minutes after the addition of cement or fly ash to the mix. The Engineer reserves the right to reduce the allowable time for placement to account for adverse weather conditions or other factors that may accelerate the stiffening of the mix.

(E) Backfill.

Backfill using materials acceptable to the Engineer. Provide borrow material unless otherwise directed by the Contract Documents. The Contractor may use suitable and available excavation materials before using borrow excavation. The Engineer must approve of all off-site borrow materials before use. The Contractor is responsible for arranging and paying all costs associated with obtaining a sufficient amount of borrow material.

The Contractor may place rocks, broken concrete, or other solid materials less than six (6) inches in size in backfill areas other than those designated for placing or driving piling as allowed by the Engineer. Cover rocks, broken PCC, or other solid materials with at least two (2) feet of embankment material.

Place backfill materials in uniform horizontal layers not exceeding eight (8) inches loose lift thickness. Construct each layer of the backfill material to the specified density before placing additional layer. Adjust the moisture content as necessary to fulfill moisture requirements. The Engineer reserves the right to alter the thickness of the lifts to meet the specific conditions of the project site. Place successive lifts in a manner that does not significantly alter the moisture content or density of previously completed lifts. Construct the first layers of backfill materials over soft, saturated ground using light, tracked equipment and lift thickness acceptable to the Engineer.

Compact the backfill material uniformly to produce a surface that does not yield under repeated loading by heavy trucks or equipment. Construct the backfill to meet the requirements of Table 103.01. The maximum dry density (Standard Effort) and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). The maximum dry density (Modified Effort) and optimum moisture shall be determined by ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

Table 103.01
Backfill Requirements

Depth Below Pavement or Finished Grade	Minimum Compaction Requirement	Acceptable Moisture Range
≤ 1 foot (under pavement and within 4 feet of the edge of pavement and under sidewalk/ bike trail)	90% of Maximum Dry Density (**Modified** Effort)	Optimum Moisture Content –3%, +4%
≤ 1 foot (beyond 4 ft of pavement or beyond edge of sidewalk / bike trail)	92% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%
Greater than 1 foot (all locations)	95% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%

Step the sides of existing natural or backfill slopes steeper than 1V:3H. The vertical depth of the step shall be less than one (1) foot and the vertical face shall be no steeper than 1V:1H. The base of the step shall be nearly horizontal. Extend the face horizontally into the existing natural or embankment slope until encountering stable soils. Horizontal cuts shall begin at the intersection of the ground line and the vertical side of the previous bench. Compact the materials excavated as part of stepping operations with the new embankment material as allowed by the Engineer.

When backfilling along a structure, compact backfill materials without applying excessive pressure against the structure. Grade embankment surfaces to be smooth and uniform. The final elevation of the embankment shall be within one-half (½) inch of the design elevation.

103.04 Measurement and Payment.

The Engineer shall measure sewer abandonment for payment as a single unit defined by the units indicated below abandoned and accepted. This contract price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Excavation for sewer abandonment and/or backfilling of any cavities or trenches created by the removal or abandonment of a sewer pipe or structure is subsidiary to items for which the Contract provides direct payment.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for removing, salvaging, storing, and disposing of all materials, breaking floors, plugging all openings, excavation, furnishing, placing and compacting backfill material, and all materials, labor, equipment, tools, and incidentals necessary to complete the work.

103 – Sewer Abandonment

Description	Unit
Abandon Sanitary Sewer Service	Each
Abandon Manhole	Each
Abandon Inlet	Each
Abandon Lift Station	Each
Abandon Siphon Structure	Each
Abandon ___ Pipe	Linear Foot
Construct ___-inch Pipe Plug	Each

104 – PAVEMENT MILLING OR REMOVAL

104.01 Description.

This work shall include the full or partial depth removal of existing driveways, walkways, pavement, pavement surfacing, headers, curb and gutter, or curb including salvaging and disposing of the materials and all necessary excavation and backfilling. This work shall include curb height restoration, surface planing, and grinding of existing ACP or PCC pavements, at locations indicated in the Contract Documents, to remove any surface irregularities to within a predetermined specified limit, in accordance with the requirements of the Contract Documents, or as directed by the Engineer.

Surface planing is defined as grinding and/or planing of existing ACP or PCC pavements, to remove any surface irregularities to within a predetermined specified limit as directed by the Contract Documents or the Engineer. Surface planing includes grinding of any dissimilar material street repairs that protrude above the grade of the proposed planed surface. Combination curb and gutter is defined as any integral concrete curb and gutter section whose combined total width is not more than three (3) feet and was not constructed integrally with an adjoining base or pavement. Classify combination curb and gutter with a combined total width greater than three (3) feet as pavement with integral curb.

104.02 Material Requirements.

None.

104.03 Construction Requirements.

(A) General Requirements.

All equipment, tools, and machinery shall be designed and of adequate capacity for the intended purpose that it is used. Maintain equipment, tools, and machinery in satisfactory working condition at all times. The Contractor is responsible for controlling any dust generated by the pavement removal process.

When milled surfaces are or will be open to traffic, the Contractor shall maintain the existing pavement markings or construct temporary pavement marking as directed by the Engineer. Remove all loose material from the pavement surface to the satisfaction of the Engineer before opening the milled surface to traffic. Channel the traffic through the project as directed by the Engineer. Transition between milled and unmilled surfaces by feathering or constructing an ACP wedge for vertical faces greater than one (1) inch. The maximum slope of such transitions shall be 1V:10H. The maximum edge drop between adjacent lanes open to traffic shall be one (1) inch. Erect warning signs notifying motorists of uneven lanes as directed by the Engineer.

Locate and protect any manholes, valve boxes, or other appurtenances, some of which may be below the surface of the street, from damage by the removal process. The City is not responsible for any damage resulting from manholes, valve boxes, or other appurtenances.

(B) Partial-Depth Milling.

Milling the pavement to the depth or to the lines and grades indicated in the Contract Documents. Use a commercially manufactured milling machine designed for the intended use. The milling machine shall be self-propelled, of sufficient weight, size, power, and traction to remove surface irregularities without tearing or displacing the remaining pavement. The cutting edge shall allow for adjustment to meet the required crown. Do not accomplish partial-depth milling by scarifying, blading, or heating. Perform partial depth removal in areas with physical or geometric constraints in a manner acceptable to the Engineer. Curb grinding machines shall be capable of grinding the PCC curb without damaging adjacent curb, pavement, or other structures.

The milling machine shall have automatic controls for establishing profile grades on each side of the machine using the existing pavement and/or a taut reference line. Reference the existing pavement using a self-contained grade reference system that references twenty-five (25) linear feet of existing pavement and compensates for humps or depressions three (3) feet or less in length. Do not use a joint matching shoe as a reference system. The Contractor is responsible for erecting and maintaining a taut reference line true to line and grade. Use automatic controls on each side of the milling machine when milling pavement unless otherwise allowed by the Engineer. Use automatic controls on the existing pavement side of the milling machine when milling curb unless otherwise allowed by the Engineer.

The milling machine shall remove the millings from the surface using a loading elevator or other means acceptable to the Engineer. Deliver the pavement millings to locations selected by the Engineer within the vicinity of the project as directed by the Engineer. Pavement millings not retained by the City shall become the property of the Contractor. Dispose of such millings outside of the Right-of-Way at a location acceptable to the Engineer.

Accomplish planing and grinding by performing multiple passes of the milling machine as necessary to remove the required surface to the depth indicated in the Contract Documents or as directed by the Engineer. Following the final pass, the planed surface shall be within one-fourth (¼) inch of the required surface when checked using a ten (10) foot straightedge.

(C) Full Depth Removal.

Saw cut or line drill the full-depth of the pavement along the perimeter of all sections of pavement designated for removal. The distance between line drilling holes shall not exceed the diameter of the hole. Once the saw cutting or line drilling is complete, the Contractor shall mill or break and remove the designated pavement in a manner acceptable to the Engineer. Perform removals in a manner that avoids undercutting any pavement designated to remain. Accomplish removal operations without damaging any cables, utility ducts, pipes, structures or other items not designated for removal or abandonment unless otherwise authorized in writing by the Engineer. Repair any unauthorized damage at no expense to the City. Unless otherwise designated in the Contract Documents, the removed pavement shall become the property of the Contractor and shall be disposed of at a location off-site.

104.04 Measurement and Payment.

The Engineer shall measure partial depth milling as a single unit defined as the number of square yards of surface area milled, disposed of, and accepted.

The Engineer shall measure full depth removal as a single unit defined as the number of square feet or square yards of pavement removed, disposed of, and accepted.

The Engineer shall measure surface planing for payment as a single unit defined as the number of square yards of pavement planed and accepted.

The Engineer shall measure curb height restoration for payment as a single unit defined by the number of linear feet of curb height restored and accepted.

The Engineer shall measure curb grinding for payment by the total number of linear feet of PCC curb ground and accepted.

The Engineer shall measure full –depth saw cutting for payment by the total number of linear feet of pavement saw cut and accepted.

Unless otherwise indicated in the Contract Documents, removal of any driveway, walkway, or pavement, excluding ACP, PCC, or bituminous surfacing driveways, walkways, or pavement, is subsidiary to items for which the Contract provides direct payment. Integral curb removed in conjunction with pavement removal shall not be measured separately but shall be measured as pavement removal. Providing transitions is subsidiary to items for which the Contract provides direct payment.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for

grinding, removal, loading, hauling, and disposal, and for furnishing all equipment, tools, traffic control devices, labor, and all incidentals necessary to complete the work.

Description	**Unit**
___ Cold Planing – Asphalt	Square Yard
___ Cold Planing – Concrete	Square Yard
___ Cold Planing - Concrete with Wire Mesh	Square Yard
Remove ___ Asphalt Surface Course	Square Yard
Remove ___ Pavement	Square Yard
Remove ___ Driveway	Square Yard
Remove Sidewalk	Square Foot
Remove Median Surfacing	Square Foot
Remove Curb	Linear Foot
Remove Combination Curb and Gutter	Linear Foot
Remove Integral Curb	Linear Foot
Remove Concrete Header	Linear Foot
Grind Existing Curb	Linear Foot
Curb Height Restoration – ___ Pavement	Linear Foot
Saw cut – Full Depth	Linear Foot

105 – BRICK PAVEMENT REMOVAL

105.01 Description.

This work includes removing; salvaging, and disposing of brick or stone block pavement, driveways, walks, steps, and cushion material as indicated in the Contract Documents including all necessary excavation and backfilling.

105.02 Material Requirements.

None.

105.03 Construction Requirements.

Remove all brick or stone block pieces and cushion or bedding materials in a manner acceptable to the Engineer. When designated by the Contract Documents, the City shall retain ownership of the brick or stone block pieces. Load and deliver such pieces to the designated location in a manner that prevents damage to the pieces. Compensate the City for any pieces damaged by the Contractor. The amount of compensation shall equal the replacement cost of the number of damaged pieces as determined by the Engineer.

105.04 Measurement and Payment.

The Engineer shall measure brick pavement removal as a single unit defined as the number of square yards of brick pavement removed, delivered or disposed of, and accepted.

The Engineer shall measure stone block pavement removal as a single unit defined as the number of square yards of stone block pavement removed, delivered or disposed of, and accepted.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for the cost of removal, salvaging, and disposal; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Remove Brick Surface	Square Yard
Remove Stone Block Surface	Square Yard

THIS PAGE INTENTIONALLY LEFT BLANK

106 – TRAFFIC SIGNAL REMOVAL

106.01 Description.

This work includes removing, salvaging, and disposal of traffic signal equipment, cabinets, poles, structures, and wiring as indicated in the Contract Documents including all necessary excavation and backfilling. Removal of PCC foundations shall extend a minimum of thirty (30) inches below the surrounding surface.

106.02 Material Requirements.

None.

106.03 Construction Requirements.

Remove and dispose of all signal poles, structures, foundations, traffic controllers, controller cabinets, signal heads, cable, wire, and miscellaneous related items at the locations indicated in the Contract Documents. Salvage and store or deliver to the designated location(s) any items identified in the Contract Documents as being reused or retained by the City.

Remove any PCC foundations to a minimum depth of thirty (30) inches below the surrounding surface.

Backfill using materials acceptable to the Engineer. Provide borrow material unless otherwise directed by the Contract Documents. The Contractor may use suitable and available excavation materials before using borrow excavation. The Engineer must approve of all off-site borrow materials before use. The Contractor is responsible for arranging and paying all costs associated with obtaining a sufficient amount of borrow material.

The Contractor may place rocks, broken concrete, or other solid materials less than six (6) inches in size in backfill areas other than those designated for placing or driving piling as allowed by the Engineer. Cover rocks, broken PCC, or other solid materials with at least two (2) feet of embankment material.

Place backfill materials in uniform horizontal layers not exceeding eight (8) inches loose lift thickness. Construct each layer of the backfill material to the specified density before placing additional layer. Adjust the moisture content as necessary to fulfill moisture requirements. The Engineer reserves the right to alter the thickness of the lifts to meet the specific conditions of the project site. Place successive lifts in a manner that does not significantly alter the moisture content or density of previously completed lifts. Construct the first layers of backfill materials over soft, saturated ground using light, tracked equipment and lift thickness acceptable to the Engineer.

Compact the backfill material uniformly to produce a surface that does not yield under repeated loading by heavy trucks or equipment. Construct the backfill to meet the requirements of Table 106.01. The maximum dry density (Standard Effort) and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). The maximum dry density (Modified Effort) and optimum moisture shall be determined by ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

Table 106.01
Backfill Requirements

Depth Below Pavement or Finished Grade	Minimum Compaction Requirement	Acceptable Moisture Range
≤ 1 foot (under pavement and within 4 feet of the edge of pavement and under sidewalk/ bike trail)	90% of Maximum Dry Density (**Modified** Effort)	Optimum Moisture Content –3%, +4%
≤ 1 foot (beyond 4 ft of pavement or beyond edge of sidewalk / bike trail)	92% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%
Greater than 1 foot (all locations)	95% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%

Step the sides of existing natural or backfill slopes steeper than 1V:3H. The vertical depth of the step shall be less than one (1) foot and the vertical face shall be no steeper than 1V:1H. The base of the step shall be nearly horizontal. Extend the face horizontally into the existing natural or embankment slope until encountering stable soils. Horizontal cuts shall begin at the intersection of the ground line and the vertical side of the previous bench. Compact the materials excavated as part of stepping operations with the new embankment material as allowed by the Engineer.

When backfilling along a structure, compact backfill materials without applying excessive pressure against the structure. Grade embankment surfaces to be smooth and uniform. The final elevation of the embankment shall be within one-half (½) inch of the design elevation.

106.04 Measurement and Payment.

The Engineer shall measure traffic signal system removal as a lump sum unit defined by the removal, disposal, backfilling, and acceptance of all traffic signal equipment, poles, wiring, ducts, and structures.

Backfilling of any cavities created by the removal of a structure or foundation is subsidiary to items for which the Contract provides direct payment.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for the cost of removal, salvaging, and disposal; excavation; backfilling; and for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Traffic Signal System Removal	Lump Sum

THIS PAGE INTENTIONALLY LEFT BLANK

107 – CRACK AND JOINT REPAIR

107.01 Description.

This work includes the routing, cleaning, and repair of random cracks or pavement joints.

107.02 Material Requirements.

(A) Joint Filler.
Joint filler material shall meet the requirements of ASTM D3405, Standard Specification for Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements.

(B) Crack Repair Fabric.
Crack repair fabric shall be a minimum of twelve (12) inches wide and meet the requirements of AASHTO M288, Geotextile Specification for Highway Applications, Section 9. Store crack repair fabric in a cool, dry location free from dust.

(C) Emulsion/Aggregate Slurry.
Emulsion/Aggregate Slurry shall meet the requirements for a Type 1 Slurry Seal Mixture as defined by ASTM D3910, Standard Practices for Design, Testing, and Construction of Slurry Seal.

(D) Bituminous Tack Coat.
Bituminous tack coat material shall meet the requirements of CSS-1 or CSS-1h as defined by ASTM D2397, Standard Specification for Cationic Emulsified Asphalt.

(E) Asphalt Binder for ACP.
Asphalt binder shall conform to the requirements of PG58-28 or PG64-22 as defined by AASHTO MP-1A, Standard Specification for Performance Graded Asphalt Binder, for the Performance Graded Binder.

(F) Aggregate for ACP.
Individual coarse aggregates shall conform to the requirements of ASTM D692, Standard Specification for Coarse Aggregate for Bituminous Paving Mixtures, and Table 3, Class 4S of ASTM C33, Specification for Concrete Aggregates, excluding any crushed pieces or gradation requirements. Crush and grade individual coarse aggregates as needed to meet the required properties.

Individual fine aggregates shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete Aggregates, and ASTM D1073, Standard Specification for Fine Aggregate for Bituminous Paving Mixtures excluding any crushed

pieces or gradation requirements. Crush and grade individual fine aggregates as needed to meet the required properties.

(G) Mineral Filler for ACP.
Individual mineral fillers added separate of coarse and fine aggregates shall meet the requirements of ASTM D242, Standard Specification for Mineral Filler for Bituminous Paving Mixtures.

(H) ACP Mix Design.
The ACP mixture shall meet the requirements of Table 107.01. Coarse aggregate is the total material retained on the #4 sieve. Fine aggregate is the total material passing the #4 sieve and retained on the #200 sieve. The Contractor is responsible for all costs associated with developing the ACP mix design.

At a minimum, Submit the following information on the proposed ACP mix design:

- Aggregate Sources, Proportions, Source Properties, and Individual and Combined Gradations;
- Individual Coarse and Fine Aggregate Specific Gravities for each component aggregate;
- Combined Aggregate Consensus Properties;
- PG Binder Source, Grade, and Target Percentage; and the Manufacturer's Recommended Mixing and Compaction Temperatures;
- ACP Physical Properties at the varying Binder Contents used to develop the ACP mix design.

Table 107.01
ACP Test Requirements

Property	Requirement
Combined Aggregate Consensus Properties*	
Coarse Aggregate - Fractured Faces, Two (2) or more Faces	80% Min.
Coarse Aggregate - Fractured Faces, One (1) or more Faces	85% Min.
Coarse Aggregate - Flat and/or Elongated Pieces, 5:1 Ratio	10% Max.
Fine Aggregate Angularity	40% Min.
Sand Equivalent Value	40 Min.
ACP Physical Property Requirements	
Compaction Gyrations – $N_{initial}$	7
Compaction Gyrations – N_{design}	75
Compaction Gyrations – $N_{maximum}$	115
Percent Compaction @ $N_{initial}$, %	≤ 90.5
Percent Compaction @ N_{design}, %	95 to 97
Percent Compaction @ $N_{maximum}$, %	≤ 98.0
Asphalt Binder Content, % of total mix	5.3 Min.
Mix Design Air Voids, %	4.0 – 5.5
Production Air Voids, %	3.0 – 5.0
Voids in Mineral Aggregate (VMA), %	Min. 15.0
Voids Filled with Asphalt (VFA), %	65 to 78
Film Thickness, Microns	9.0 min.
Filler To Effective Binder Ratio	0.6 - 1.6
Tensile Strength Ratio (TSR), %**	80 Min.
Combined Aggregate Grading, % Passing	
1" Sieve	
¾" Sieve	
½" Sieve	100
⅜" Sieve	90 to 100
#8 Sieve	32 to 67
#200 Sieve	0 to 5

* Based on virgin materials only.
** Including Freeze-thaw procedure.

Referenced Test Procedures.

- AASHTO MP-1a, Performance Graded Asphalt Binder
- AASHTO MP-2, Specification for Superpave Volumetric Mix Design
- AASHTO PP-19, Practice for Volumetric Analysis of Compacted Hot-Mix Asphalt (HMA)
- AASHTO PP-28, Practice for Superpave Volumetric Design for Hot-Mix Asphalt (HMA)
- AASHTO T283, Resistance of Compacted Bituminous Mixture to Moisture Induced Damage
- Asphalt Institute Manual MS-2, Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types
- Asphalt Institute Manual SP-2, Superpave Level 1 Mix Design
- ASTM C33, Standard Specification for Concrete Aggregates
- ASTM C1252, Standard Test Method for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading) – Test Method A

- ASTM D8, Standard Terminology Relating to Materials for Roads and Pavements
- ASTM D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
- ASTM D2419, Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
- ASTM D3203, Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
- ASTM D3665, Practice for Random Sampling of Construction Materials
- ASTM D3666, Specification for Minimum Requirements of Agencies Testing and Inspecting Bituminous Paving Materials
- ASTM D4781, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
- ASTM D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
- ASTM D5444, Test Method for Mechanical Size Analysis of Extracted Aggregate
- ASTM D6307, Standard Test Method for Asphalt Content of Hot-Mix Asphalt by Ignition Method

107.03 Construction Requirements.

(A) Crack and Joint Repair – Type "A".

Remove all existing crack filler, sealer, debris, and vegetation from the designated joints and cracks. Accomplish the removal using a scraping device, router, air compressor, or other suitable equipment as necessary to produce a surface to which crack and joint filler can adhere. Router all joints and cracks narrower than one-half (½) of an inch wide to a minimum width of one-half (½) of an inch. The minimum depth of a routered joint or crack shall be three-fourths (¾) of an inch below the pavement surface. Remove all loose or spalled material from cracks and joints wider than one-half (½) of an inch to a minimum depth of one (1) inch. Apply the crack and joint filler to the prepared crack or joint in accordance with the manufacturer’s recommendations.

(B) Crack and Joint Repair – Type "B".

Mill the designated crack or joint to a minimum depth of two (2) inches and a maximum depth of four (4) inches as determined by the Engineer. The width of the milling shall be a minimum of twelve (12) inches and a maximum of eighteen (18) inches centered on the crack or joint as equally as possible. Remove all loose particles from the milled crack or joint and apply a bituminous tack coat to the bottom and sides of the milled trench. As directed by the Engineer, the Contractor shall place crack repair fabric along the crack or joint in the milled trench. Install the crack repair fabric in accordance with the manufacturer's recommendations.

Fill the milled trench with ACP patching material in one (1) or more lifts. Place ACP mixtures on dry, unfrozen surfaces. The minimum acceptable atmospheric temperature shall be forty (40) degrees Fahrenheit. The minimum acceptable base temperature shall be thirty (35) degrees Fahrenheit. The minimum placement temperature of ACP shall be at or above the manufacturer's recommended compaction temperature for the PG Binder used. The Engineer reserves the right to waive the temperature limitations. Waiving the temperature limitations does not relieve the Contractor of any other requirements stated in the Contract Documents.

The asphalt mixing plant shall meet the requirements of ASTM D995, Standard Specification for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures. For batch plants, the minimum dry mixing period shall be five (5) seconds and the minimum wet mixing period shall be twenty-five (25) seconds. All mixing plants shall have automatic controls for proportioning, timing, and discharge.

Transport the ACP mixture in vehicles with tight, clean, smooth metal beds. The Contractor may lightly coat the bed with an approved asphalt release agent as allowed by the Engineer. Do not coat the bed with petroleum oils, solvents, or other material unacceptable to the Engineer. Cover all loads during adverse weather conditions, or when atmospheric temperatures are below sixty-five (65) degrees Fahrenheit, or when directed by the Engineer. Insulate the sides of the truck beds in a manner acceptable to the Engineer from October 15th to March 15th.

Compact the ACP mixture using rollers capable of reversing without shoving or tearing the mixture. Vibratory rollers shall have separate energy and propulsion controls. Rubber-tired rollers shall have tire pressures as recommended by the manufacturer. A combination steel drum/rubber tire roller is unacceptable. Select the number, size, and type of equipment that will achieve proper compaction without displacing the mixture or crushing the aggregate. Keep a minimum of three (3) rollers on-site and available for use at all times.

The number, weight, types of rollers, sequence of rolling operations, and compaction procedures shall be such that the required density and a satisfactory surface are consistently attained while the mixture is in a workable condition. In areas inaccessible to standard rolling equipment, compact ACP to the required density in a manner acceptable to the Engineer. After final compaction, verify that the ACP surface of the asphaltic concrete is smooth and true to the established crown and grade.

Compact the ACP to the minimum of ninety-two (92) percent of the maximum theoretical density determined in accordance with ASTM

D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.

The maximum allowable deviation from the specified elevation is minus zero (-0), plus one-half (+½) inch provided the deviation does not alter the designed drainage pattern. The finished surface shall be smooth and free of bumps or depressions greater than one-fourth (¼) inch when tested with a ten (10) foot straight edge. Repair non-conforming areas by removing a sufficient amount of material to allow for the construction of a lift of ACP three (3) times the nominal maximum aggregate size. Remove high spots by grinding using a diamond tipped grinding wheel or other equipment acceptable to the Engineer. Perform all repairs at no additional expense to the City.

(C) Crack and Joint Repair – Type "C".

Remove all existing crack filler, sealer, debris, and vegetation from the designated joints and cracks. Accomplish the removal using a scraping device, router, air compressor, or other suitable equipment as necessary to produce a surface to which crack and joint filler can adhere. Router all designated cracks or joints narrower than two (2) inches wide to a minimum width of two (2) inches. Remove all loose or spalled material from the designated cracks or joints. Fill the crack or joint with the emulsion/aggregate slurry. The finished surface of the emulsion/aggregate slurry shall match the elevation of the surrounding surfaces with a tolerance of ± one-fourth (¼) of an inch. Remove excess slurry material immediately. Correct any damage resulting from the application of excess slurry material to the satisfaction of the Engineer at no additional cost to the City. Protect the slurry material from traffic for a minimum of twelve (12) hours.

107.04 Measurement and Payment.

The Engineer shall measure crack and joint repair as a single unit defined by the linear feet of crack and joint repaired in accordance with the specified method and accepted.

The Engineer shall measure crack repair fabric as a single unit defined by the number of linear feet of each type and nominal width of crack repair fabric installed and accepted.

All costs associated with developing the ACP mix design are subsidiary to items for which the Contract provides direct payment.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Crack and Joint Repair – Type "A"	Linear Foot
Crack and Joint Repair – Type "B"	Linear Foot
Crack and Joint Repair – Type "C"	Linear Foot
Crack Repair Fabric (___" Nominal Width)	Linear Foot

THIS PAGE INTENTIONALLY LEFT BLANK

200 EARTHWORK

201 – EXCAVATION AND EMBANKMENT

201.01 Description.

This work includes excavating, placing, shaping, compacting, and sloping necessary for the construction, preparation and completion of all embankments, subgrade, roadways, slopes, ditches, intersections, approaches, driveways, foundations, concrete seal courses, box culverts, pipe-arch culverts, pipe-arch culverts, structural plate pipe and pipe-arch culverts, headwalls, retaining walls, steps, and other miscellaneous items in conformance with the alignments, grades, and typical cross sections within the limits of construction as indicated in the Contract Documents. The work includes removal and disposal of culverts, foundations, structures, other protruding obstructions, and all materials encountered, including rock, boulders, earth and muck, except the removal of items that the Contract provides direct payment, to the extent necessary for completing all work outlined in the Contract Documents or as directed by the Engineer.

The Contractor shall compact the upper twelve (12) inches of the roadbed within excavation areas to conform with the compaction requirements for embankments. The Contractor shall perform all work required, including the application of water if necessary to facilitate compaction, to accomplish compaction of suitable materials at no additional cost to the City. The work shall include bailing, draining, pumping, sheathing, construction of cofferdams or temporary cribs, removal of such cofferdams or temporary cribs, backfilling, and disposal of all excess materials obtained from excavation.

201.02 Material Requirements.

(A) Borrow Material.
Borrow material shall consist of silt (ML), silty clay (CL-ML) or lean clay (CL) materials as determined in accordance with ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes. Borrow material shall be free of debris, vegetation, or organic matter. The Engineer must approve all borrow material in writing before use by the Contractor.

(B) Unsuitable Material.
Unsuitable material may consist of saturated and unstable soils, or soils containing organic matter, debris, or vegetation unacceptable for use as embankment or subgrade material. The Engineer shall determine if the soil material is unsuitable material.

(C) Granular Foundation Course.

Granular foundation course material shall be a porous, free-draining limestone, dolomite, quartzite, crushed gravel, or recycled PCC. Granular foundation course material shall meet the requirements of Table 201.01 and ASTM D2940, Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports, excluding any gradation requirements. The maximum particle size shall be three (3) inches in diameter.

Table 201.01
Aggregate Physical Property Requirements

Physical Property	Acceptable Range
Sodium Sulfate Soundness, ASTM C88 (5 cycles)*	10.0% maximum loss
Magnesium Sulfate Soundness, ASTM C88 (5 cycles)*	15.0% maximum loss
Freeze-Thaw Soundness, AASHTO T103 (15 cycles)*	15.0% maximum loss
LA Abrasion, ASTM C131 and ASTM D535	40.0% maximum loss
Absorption, ASTM C127 and ASTM C128	3.0% maximum

*Only one of the three soundness requirements must be fulfilled.

201.03 Construction Requirements.

(A) General.

Perform all required clearing and grubbing activities before beginning excavation, grading, or embankment operations. Maintain adequate drainage in all grading areas in a manner acceptable to the Engineer. Protect embankments from damage due to erosion. Conduct all grading operations without disturbing any materials, equipment, or structures outside the limits of construction. Grade slopes to drain unless otherwise directed by the Engineer or the Contract Documents.

Use equipment in satisfactory working condition and designed for use in the manner proposed. Use compaction equipment and techniques that consistently produce the required compaction throughout the depth of the compacted lift. Do not use equipment that produces a smooth, glossy surface or detrimental laminations within the compacted lifts.

Use techniques that avoid damaging telephone, telegraph or power poles located within the limits of the proposed construction. Notify the Engineer of any poles that interfere with the proposed work. Repair any damage to the poles or related services to the satisfaction of the pole owner at no additional cost to the City.

(B) Excavation.

Excavate and either use or dispose of all common material(s) encountered to the lines and grades indicated in the Contract Documents. Grade excavation surfaces to be smooth and uniform. The finished elevation of the excavation shall be within one-half (½) inch of the design elevation.

Excavate the channel before commencing any bridge or culvert work. The Engineer reserves the right to allow a temporarily suspension of channel excavation activities after completing channel excavation at the bridge or culvert location if a temporary ditch is constructed for drainage. Maintain completed channels free from debris until accepted by the Engineer.

Dispose of surplus excavated material in a manner acceptable to the Engineer. Do not place excess material in wetlands or other legally protected areas. The Engineer must approve the wasting of any excavated material. At the discretion of the Engineer, the Contractor may use suitable surplus material to widen embankments and flatten slopes within the right-of-way. Obtain written arrangements with property owners and governmental authorities for disposal locations outside the Right-of-Way limits. Grade abandoned roadways to match the existing or original ground contour.

(C) Unsuitable Excavation.

Construct embankments using materials acceptable to the Engineer. The Engineer shall identify unsuitable materials. Remove all unsuitable materials to the depth required by the Contract Documents or as directed by the Engineer. After removal of the unsuitable materials, backfill the excavations by in accordance with the requirements for embankment. Dispose of unsuitable excavated material in a manner acceptable to the Engineer. Do not place unsuitable material in wetlands or other legally protected areas.

(D) Embankment.

Provide borrow material unless otherwise directed by the Contract Documents. The Contractor may use suitable and available suitable excavation materials before using borrow excavation. Do not obtain borrow material from any location on the project that is not identified as a borrow area in the Contract Documents or by the Engineer. The Contractor is responsible for obtaining all necessary permits and approvals associated with the use of individual off-site borrow locations. Before commencing use of each individual off-site borrow location, provide maps and written documentation detailing site location and conditions to the Engineer.

The Engineer must approve of all off-site borrow materials before use. When requested by the Engineer, furnish a certified hazardous waste site assessment for borrow areas located off the Right-of-Way. Provide an alternate borrow source or conduct more detailed hazardous waste testing at suspect locations at no additional cost to the City. The Engineer reserves the right to not allow material from a suspect borrow area.

Remove all organic matter from the underlying ground before beginning embankment construction. After removing all organic

material and before commencing embankment construction, scarify the underlying surface to a minimum depth of six (6) inches, and then compact the scarified materials to the specified embankment density. Place of rocks, broken concrete, or other solid materials less than six (6) inches in size in embankment areas other than those designated for placing or driving piling as allowed by the Engineer. Distribute such materials to avoid pockets or nests. Fill any voids between such materials. Cover solid materials with at least two (2) feet of embankment material. Do not place frozen materials in the embankment.

Scarify existing roadways to a minimum depth of six (6) inches and uniformly distribute the scarified materials across the full width of the embankment before commencing embankment construction.

Place embankment materials in uniform horizontal layers not exceeding eight (8) inches loose lift thickness. Construct each layer of the embankment material to the specified density before placing additional layer. Level each layer before commencing compaction efforts. Adjust the moisture content as necessary to fulfill moisture requirements. The Engineer reserves the right to alter the thickness of the lifts to meet the specific conditions of the project site. Place successive lifts in a manner that does not significantly alter the moisture content or density of previously completed lifts. Construct the first layers of embankment materials over soft, saturated ground using light, tracked equipment and lift thickness acceptable to the Engineer.

Compact the embankment material uniformly to produce an embankment that does not yield under repeated loading by heavy trucks or equipment. Construct the backfill to meet the requirements of Table 201.02. The maximum dry density (Standard Effort) and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). The maximum dry density (Modified Effort) and optimum moisture shall be determined by ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

Table 201.02
Embankment Requirements

Depth Below Pavement or Finished Grade	Minimum Compaction Requirement	Acceptable Moisture Range
≤ 1 foot (under pavement and within 4 feet of the edge of pavement and under sidewalk/ bike trail)	90% of Maximum Dry Density (Modified Effort)	Optimum Moisture Content –3%, +4%
Greater than 1 foot (all locations)	95% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%
≤ 1 foot (beyond 4 ft of pavement or beyond edge of sidewalk / bike trail)	92% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%

Step the sides of existing natural or embankment slopes steeper than 1V:3H. The vertical depth of the step shall be less than one (1) foot and the vertical face shall be no steeper than 1V:1H. The base of the step shall be nearly horizontal. Extend the face horizontally into the existing natural or embankment slope until encountering stable soils. Horizontal cuts shall begin at the intersection of the ground line and the vertical side of the previous bench. Compact the materials excavated as part of stepping operations with the new embankment material as allowed by the Engineer.

When backfilling along a structure, compact embankment materials without applying excessive pressure against the structure. Limit the placement or embankment adjacent to a bridge to a level equal to the base of the backwall elevation until the superstructure is in place. Place embankment on all sides the structure simultaneously.

Grade embankment surfaces to be smooth and uniform. The final elevation of the embankment shall be within one-tenth (0.1) foot of the design elevation.

201.04 Measurement and Payment.

The Engineer shall measure excavation as a single unit defined as the number of cubic yards of material excavated and accepted. The Engineer shall measure the volume of material excavated in its original position by the method of average end areas of the material actually removed and will include authorized excavation of material below grade. The Engineer reserves the right to verify the excavation quantity by cross-sections performed at intervals less than or equal to two hundred fifty (250) feet. The Engineer shall exclude suitable materials temporarily removed and replaced to aid in compaction efforts.

The Engineer shall measure unsuitable excavation as a single unit defined as the number of cubic yards of material excavated and accepted. The

Engineer shall measure the volume of unsuitable material excavated in its original position by the method of average end areas of the material actually removed and will include authorized excavation of material below grade. The Engineer reserves the right to verify the unsuitable excavation quantity by cross-sections performed at intervals less than or equal to two hundred fifty (250) feet.

The Engineer shall measure embankment as a single unit defined as the number of cubic yards of embankment constructed and accepted. The Engineer shall measure the volume of embankment constructed in its final position (actual amount of embankment constructed, not borrow material excavated). The Engineer will not include any surplus material placed outside the limits identified in the Contract Documents or directed by the Engineer in the measurement for payment. The Engineer reserves the right to verify the embankment quantity by cross-sections performed at intervals less than or equal to two hundred fifty (250) feet.

All costs associated with obtaining and excavating a sufficient amount of borrow materials are subsidiary to items for which the Contract provides direct payment. Any cost associated with obtaining permits or approvals is subsidiary to items for which the Contract provides direct payment. The cost of stockpiling or excavation of stockpiled materials before use or during the performance of the work is subsidiary to items for which the Contract provides direct payment. Scarifying existing roadways is subsidiary to items for which the Contract provides direct payment. The cost of delays due to the telephone, telegraph or power poles located within the limits of the proposed construction is incidental to excavation or embankment construction.

The Engineer shall measure granular foundation course material as a single unit defined as the number of tons of material supplied and placed.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. This contract price shall be full compensation for excavating, embankment construction, material hauling, stockpiling, preparing slopes, stepping, disposal of surplus and unsuitable material, grading, shaping, manipulation of excavation or embankment materials, compacting, watering, re-compacting, and finishing and for furnishing of all labor, equipment, tools and, incidentals necessary to complete the work.

Description	**Unit**
Earthwork (Excavation)	Cubic Yard
Earthwork (Unsuitable Excavation)	Cubic Yard
Earthwork (Embankment)	Cubic Yard
Granular Foundation Course	Ton

202 – SUBGRADE PREPARATION

202.01 Description.

This work includes minor grading, shaping, scarifying, drying, watering, reshaping, compacting, and finishing embankments and excavated areas in the roadbed using grading equipment and hand work to produce a smooth surface conforming with the lines, grades and typical cross sections indicated in the Contract Documents or established by the Engineer and disposing of surplus material. This work includes trimming the subgrade to match lines, grades and typical cross sections and adjusting grade lines to meet intersections, pavements, bridge ends, railroad crossing, or any other physical features identified in the Contract Documents or designated by the Engineer. This work includes reconstructing the subgrade after removing existing pavements in preparation for pavement reconstruction.

202.02 Material Requirements.

None.

202.03 Construction Requirements.

Shape the subgrade over the full width of the roadway to an elevation between zero and one tenth (0.0 –0.1) foot above the finished grade elevation.

Excavate and dispose of any faulty subgrade or unsuitable foundation materials identified by the Engineer. Replace such materials using suitable soils, a crushed aggregate or recycled concrete base course, or other method of stabilization selected by the Engineer to the lines and grades indicated in the Contract Documents or as directed by the Engineer. Repair unsuitable foundation soils caused by the Contractor's operations at no additional cost to the City.

Compact the embankment material uniformly to produce a subgrade that does not yield under repeated loading by heavy trucks or equipment. Construct the backfill to meet the requirements of Table 202.01. The maximum dry density (Standard Effort) and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). The maximum dry density (Modified Effort) and optimum moisture shall be determined by ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

Table 202.01
Subgrade Requirements

Depth Below Pavement or Finished Grade	Minimum Compaction Requirement	Acceptable Moisture Range
≤ 1 foot (under pavement and within 4 feet of the edge of pavement and under sidewalk/ bike trail)	90% of Maximum Dry Density (Modified Effort)	Optimum Moisture Content –3%, +4%
Greater than 1 foot (all locations)	95% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%
≤ 1 foot (beyond 4 ft of pavement or beyond edge of sidewalk / bike trail)	92% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%

Grade the subgrade surface to be smooth and before constructing the base or surface course. The maximum allowable variation from the prescribed elevation is one-half (½) inch. Trimmed material not needed for the construction of additional embankment width may be temporarily stored for use in shoulder construction, pavement backfill, or flattening embankment slopes. Stockpile or windrow such material in a manner and at such locations that allow for adequate drainage away from the subgrade, subbase, or base course. Do not store such material in the traveled way when traffic is to be maintained through the construction area. Dispose of all excess trimmed material in a manner acceptable to the Engineer. Maintain the prepared subgrade until construction of base or surface course is complete. Correct all damaged sections to fulfill the requirements of Table 202.01 before constructing the base or surface course.

202.04 Measurement and Payment.

Unless otherwise indicated in the Contract Documents, subgrade preparation is subsidiary to items for which the Contract provides direct payment. Excavation or embankment construction within three-tenths (0.3) foot or less of final subgrade elevation is incidental to subgrade preparation.

When indicated in the Contract Documents, the Engineer shall measure subgrade preparation for payment as a single unit defined by the number of stations of subgrade prepared and accepted. A station shall be defined as a one hundred (100) foot increment in the longitudinal direction along the project baseline, full width in the transverse direction.

The Engineer shall measure removing and replacing faulty subgrade or unsuitable foundation soils for payment as a single unit defined by the number of cubic yards removed, replaced, and accepted. The Engineer shall measure the volume of material removed and replaced by identifying an initial cross-section before removal and a final cross-section after removal. The difference between the initial and final cross sections shall be the measured quantity.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. This contract price shall be full compensation for removing, replacing, material hauling, stockpiling, preparing slopes, disposal of surplus and unsuitable material, grading, shaping, scarifying, manipulation of materials, compacting, watering, re-compacting, and finishing and for furnishing of all labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Subgrade Preparation	Station
Faulty Subgrade-Remove and Replace	Cubic Yard

THIS PAGE LEFT INTENTIONALLY BLANK

203 – FLY ASH STABILIZATION

203.01 Description.

This work includes the supplying and incorporation of fly ash into soils and subgrade. The work of fly ash stabilization shall include minor grading, scarifying, drying, watering, reshaping compacting, and finishing of stabilized areas in the roadbed using grading equipment and hand work to produce a smooth surface conforming with the lines, grades and typical cross sections indicated in the Contract Documents or established by the Engineer and disposing of surplus material. The work of fly ash stabilization shall include adjusting grade lines to meet intersections, pavements, bridge ends, railroad crossing, or any other physical features designated by the Engineer.

203.02 Material Requirements.

Fly ash shall conform to the requirements for Class C Fly Ash of ASTM C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.

203.03 Construction Requirements.

The Engineer shall determine if fly ash stabilization is required for a given condition. Do not attempt fly ash incorporation if the air temperature is less than thirty-five (35) degrees Fahrenheit. Do not incorporate fly ash into frozen soils. Keep a water truck with water available at the project before fly ash spreading begins. The Engineer reserves the right to suspend fly ash stabilization operations if jobsite or weather conditions become unfavorable.

Spread the fly ash in a manner acceptable to the Engineer. The application rate for the fly ash shall be fifteen (15) pounds per cubic foot of soil. The Engineer reserves the right to increase or decrease the application rate to meet specific soil conditions.

Uniformly incorporate the fly ash into the soil or subgrade using a rotary pulverizer or other techniques acceptable to the Engineer. The Engineer shall approve the method of incorporation before fly ash spreading begins. The Engineer reserves the right to allow incorporation of the fly ash using a disk when the only intended use is to lower the moisture content of the soil or subgrade. The Engineer reserves the right to require the Contractor to construct a test strip of nine hundred (900) square yards or less to verify that the proposed method of incorporation is satisfactory.

Begin compaction efforts immediately after incorporation is complete and within one (1) hour of the start of spreading. Compact the fly ash/soil material uniformly to produce a compacted soil that does not yield under repeated loading by heavy trucks or equipment. Prepare and compact the

fly ash stabilized soils to meet the requirements of Table 203.01. Determine the maximum dry density and optimum moisture in accordance with ASTM D558, Standard Test Method for Moisture-Density Relations of Soil-Cement Mixtures. Adjust the moisture content of the fly ash/soil combination to meet the range required by adding and incorporating additional fly ash or water. Do not lower the moisture content by aeration. Complete compaction efforts within two (2) hours of the start of spreading

Table 203.01
Fly Ash Stabilization Requirements

Minimum Compaction	Acceptable Moisture Range
95% of Maximum Dry Density	Optimum Moisture Content –5%, +3%

Grade the surface to be smooth. The maximum allowable variation from the prescribed elevation is one-half (½) inch. Maintain the fly ash treated material until construction of subsequent layers is complete. Correct all finished sections damaged during construction operations to fulfill the requirements of Table 203.01 before constructing subsequent layers.

203.04 Measurement and Payment.

Unless otherwise indicated in the Contract Documents, fly ash incorporation is subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure fly ash as a single unit defined as the number of tons of fly ash incorporated.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. This contract price shall be full compensation for transporting and for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Fly Ash	Ton

204 – FLOWABLE FILL

204.01 Description.

This work includes supplying and placing of flowable fill to the lines, grades and typical cross sections indicated in the Contract Documents or established by the Engineer.

204.02 Material Requirements.

Store all materials from different sources separately and in a manner acceptable to the Engineer. Store cementitious materials in watertight bins.

(A) Portland Cement for Flowable Fill.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2, and Table 4.

(B) Aggregate for Flowable Fill.
Aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete. Keep aggregate materials moist for twenty-four (24) hours before use in the mixture.

(C) Fly Ash for Flowable Fill.
Fly ash shall conform to the requirements of Class C Fly Ash as defined by ASTM C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.

(D) Water for Flowable Fill.
All water used in the flowable fill mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(E) Admixtures for Flowable Fill.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. An accredited laboratory shall certify that each admixture meets the requirements of the appropriate ASTM Designation. Dosages shall be as directed by the manufacturer.

(F) Flowable Fill Mix Proportioning and Required Properties.
Prepare and submit a flowable fill mix design that identifies the component materials, the proportion of such materials, the twenty-eight (28) day compressive strength, and the air content. Flowable fill shall have a twenty-eight (28) day compressive strength of 75±50 psi and an

air content of 10±3%. Proportion the materials to produce a mixture with a consistency that flows under a very low head. Determine compressive strength in accordance with ASTM D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders. Determine air content in accordance with ASTM D6023, Standard Test Method for Unit Weight, Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM).

204.03 Construction Requirements.

The National Ready Mixed Concrete Association must certify the flowable fill production facility. Mixing times shall conform to the requirements of ASTM C94, Specification for Ready-Mixed Concrete. Hand mixing is not allowed. The production facility shall supply a load ticket with the actual batch weights of component materials.

Thoroughly mix all water added at the project site in accordance with the recommendations stated in ACI 305, Hot Weather Concreting. Measure all water added to the mix. Do not exceed the water cement ratio as stated in the flowable fill mix design approved by the Engineer. Do not add water after discharge of the flowable fill from the mixer has begun.

Place flowable fill within ninety (90) minutes after the addition of cement or fly ash to the mix. The Engineer reserves the right to reduce the allowable time for placement to account for adverse weather conditions or other factors that may accelerate the stiffening of the mix.

204.04 Measurement and Payment.

The Engineer shall measure flowable fill as a single unit defined as the number of cubic yards supplied and constructed.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. This contract price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work:

Description	Unit
Flowable Fill	Cubic Yard

300 AGGREGATE SURFACES AND BASES

301 – AGGREGATE SUBBASE/BASE COURSE

301.01 Description.

The work includes furnishing, placing, shaping, scarifying, drying, watering, and compacting an aggregate subbase/base course to provide a firm and stable foundation for subsequent construction in accordance with the lines, grades, and typical cross sections indicated in the Contract Documents. The work includes scarifying, adding additional crushed rock, drying, watering, reshaping and compacting an existing crushed rock subbase/base course to provide a firm and stable foundation for subsequent construction in accordance with the lines, grades, and typical cross sections indicated in the Contract Documents.

301.02 Material Requirements.

(A) Aggregate.

Aggregate for subbase or base shall meet the requirements of ASTM D2940, Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports and Table 301.01.

Table 301.01
Aggregate Physical Property Requirements

Physical Property	Acceptable Range
Sodium Sulfate Soundness, ASTM C88 (5 cycles)*	10.0% maximum loss
Magnesium Sulfate Soundness, ASTM C88 (5 cycles)*	15.0% maximum loss
Freeze-Thaw Soundness, AASHTO T103 (15 cycles)*	15.0% maximum loss
LA Abrasion, ASTM C131 and ASTM D535	40.0% maximum loss
Absorption, ASTM C127 and ASTM C128	3.0% maximum

*Only one of the three soundness requirements must be fulfilled.

(B) Biaxial Geotextile Grid.

The biaxial geotextile grid shall be a type specifically manufactured for reinforcement applications. It shall consist of a network of integrally connected polymer tensile elements. The aperture size shall allow for mechanical interlock of the surrounding materials. The geogrid shall have tensile and junction strength elements and shall be constructed of either a polyethylene, polypropylene or high-tenacity polyester that resists deformation due to dynamic forces. Table 301.02 illustrates the minimum average roll values (MARV) required for biaxial geotextile grid.

Table 301.02
Biaxial Geotextile Grid Requirements

Physical Property	Cross Machined Direction	Machined Direction
Tensile Strength at 2% Strain	450 lb/ft	280 lb/ft
Tensile Modulus	24,700 lb/ft	15,200 lb/ft
Ultimate Grid Junction Strength	490 lb/ft	
Flexural Stiffness	250,000 mg-cm	

Referenced Test Procedures:

- ASTM D4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
- GRI-GG2, Standard Test Method for Geogrid Junction Strength
- ASTM D1388, Standard Test Method for Stiffness of Fabrics – (Option A)

(C) Geotextile Fabric.

Geotextile fabric shall meet the requirements of AASHTO M288, Geotextile Specification for Highway Applications for the type and use indicated in the Contract Documents.

301.03 Construction Requirements.

(A) Aggregate Subbase/Base Construction.

Use equipment in satisfactory working condition and designed for use in the manner proposed. Use hauling equipment equipped for dumping material into spreader boxes, piles, or windrows and acceptable to the Engineer. Use equipment constructed and maintained to prevent loss or segregation of materials during hauling or handling operations. Use material gages, levelers, and spreader boxes that deliver a uniform quantity of material. Use compaction equipment and techniques that consistently produce the required compaction throughout the depth of the compacted lift. Do not use equipment that produces a smooth, glossy surface or detrimental laminations within the compacted lifts.

Haul, uniformly place, and compact the aggregate without causing segregation or displacing or damaging the underlying subgrade or subbase. The maximum thickness of a compacted lift of aggregate material shall be six (6) inches. Use methods and equipment that do not produce laminated surfaces between lifts of aggregate material. Scarify reconstructed aggregate layers to the depth of the underlying material or a minimum depth of four (4) inches before reworking.

Do not place aggregate material if the ambient air temperature is below thirty-five (35) degrees Fahrenheit. Shape the aggregate material to produce a uniform surface meeting the requirements for line and grade as required by the Contract Documents unless otherwise directed by the Engineer.

Compact the aggregate subbase/base material to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. Maintain the moisture content of the aggregate material in a range that facilitates achieving the required compaction.

Construct the aggregate subbase/base to a thickness within one-half (½) inch of the thickness indicated in the Contract Documents. The Engineer shall conduct thickness measurements after the Contractor has completed final grading. Correct all non-conforming areas in a manner acceptable to the Engineer. Scarify areas deficient in thickness before adding additional material.

Protect the compacted and finished crushed rock subbase/base until completion of the construction of subsequent layers. Repair any damaged area at no additional cost to the City.

(B) Geotextile Geogrid Installation.

Install geosynthetic geogrid in accordance with the manufacturer's recommendations. The recommendations shall include methods for temporarily securing uncovered segments, connection or splicing procedures to provide continuity, and overlap requirements. At a minimum, overlap adjacent strips of geogrid materials twelve (12) inches in all directions. Tracked construction equipment shall not pass over uncovered geosynthetic geogrid. Rubber-tired equipment working atop geogrid material shall operate at speeds less than ten (10) miles per hour and shall avoid any sudden stops or turns except in case of emergency. Repair any damage to uncovered geogrid or fabric at no additional cost to the City.

(C) Geotextile Fabric Installation.

Install geosynthetic geotextile fabric in accordance with the manufacturer's recommendations and AASHTO M288, Geotextile Specification for Highway Applications for the type and use indicated in the Contract Documents. The manufacturer’s recommendations shall include methods for temporarily securing uncovered segments, connection or splicing procedures to provide continuity, and overlap requirements. Tracked construction equipment shall not pass over uncovered geosynthetic geotextile fabric. Rubber-tired equipment working atop geotextile fabric shall operate at speeds less than ten (10) miles per hour and shall avoid any sudden stops or turns except in case of emergency. Repair any damage to uncovered geotextile fabric at no additional cost to the City.

301.04 Measurement and Payment.

The Engineer shall measure aggregate subbase course for payment by the number of square yards or number of tons of material supplied, constructed, and accepted.

The Engineer shall measure aggregate base course for payment by the number of square yards or number of tons of material supplied, constructed, and accepted.

The Engineer shall measure geosynthetic geogrid for payment by the number of square yards of geogrid supplied, installed, and accepted excluding the overlapped quantity.

The Engineer shall measure geosynthetic geotextile fabric for payment by the number of square yards of geotextile fabric supplied, installed, and accepted excluding the overlapped quantity.

Reworking aggregate layers is subsidiary to items that the Contract provides direct payment. Addition of water to maintain the moisture content is subsidiary to items that the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation furnishing and placing, and for the cost for all materials, equipment, labor, tools, and incidentals necessary to complete the work:

Description	Unit
Aggregate Subbase Course	Square Yard
Aggregate Subbase Course	Ton
Aggregate Base Course	Square Yard
Aggregate Base Course	Ton
Geogrid	Square Yard
Geotextile Fabric	Square Yard

302 – AGGREGATE SURFACE COURSE

302.01 Description.

This work shall include furnishing, placing, shaping, scarifying, drying, watering, and compacting an aggregate surface course to provide a firm and stable surface in accordance with the lines, grades, and typical cross sections indicated in the Contract Documents.

302.02 Material Requirements.

Aggregate surface material shall meet the requirements of ASTM D2940, Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports and Table 302.01 excluding any gradation requirements. The aggregate gradation shall conform to the requirements of Table 302.02.

Table 302.01
Aggregate Physical Property Requirements

Physical Property	Acceptable Range
Sodium Sulfate Soundness, ASTM C88 (5 cycles)*	10.0% maximum loss
Magnesium Sulfate Soundness, ASTM C88 (5 cycles)*	15.0% maximum loss
Freeze-Thaw Soundness, AASHTO T103 (15 cycles)*	15.0% maximum loss
LA Abrasion, ASTM C131 and ASTM D535	40.0% maximum loss
Absorption, ASTM C127 and ASTM C128	3.0% maximum

*Only one of the three soundness requirements must be fulfilled.

Table 302.02
Aggregate Physical Property Requirements

Sieve Size	Allowable Percent Passing
1”	100
#4	20-60
#10	0-30
#200	0-5

302.03 Construction Requirements.

Use equipment in satisfactory working condition and designed for use in the manner proposed. Use hauling equipment equipped for dumping material into spreader boxes, piles, or windrows and acceptable to the Engineer. Use equipment constructed and maintained to prevent loss or segregation of materials during hauling or handling operations. Use material gages, levelers, and spreader boxes that deliver a uniform quantity of material. Use compaction equipment and techniques that consistently produce the required compaction throughout the depth of the compacted lift. Do not use equipment that produces a smooth, glossy surface or detrimental laminations within the compacted lifts.

Haul, uniformly place, and compact the aggregate without causing segregation or displacing or damaging the underlying subgrade or subbase. The maximum thickness of a compacted lift of aggregate material shall be six (6) inches. Use methods and equipment that do not produce laminated surfaces between lifts of aggregate material. Scarify reconstructed aggregate layers to the depth of the underlying material or a minimum depth of four (4) inches before reworking.

Do not place aggregate material if the ambient air temperature is below thirty-five (35) degrees Fahrenheit. Shape the aggregate material to produce a uniform surface meeting the requirements for line and grade as required by the Contract Documents unless otherwise directed by the Engineer.

Compact the aggregate surface material to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. Maintain the moisture content of the aggregate material in a range that facilitates achieving the required compaction.

Construct the aggregate surface course to a thickness within one-half (½) inch of the thickness indicated in the Contract Documents. The Engineer shall conduct thickness measurements after the Contractor has completed final grading. Correct all non-conforming areas in a manner acceptable to the Engineer. Scarify areas deficient in thickness a minimum of three (3) inches before adding additional material.

Protect the compacted and finished crushed rock subbase/base until completion of the construction of subsequent layers. Repair any damaged area at no additional cost to the City.

302.04 Measurement and Payment.

The Engineer shall measure aggregate surface course for payment by the number of square yards or tons of material constructed and accepted.

Reworking aggregate layers is subsidiary to items that the Contract provides direct payment. Addition of water to maintain the moisture content is subsidiary to items that the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation furnishing and placing, and for the cost for all materials, equipment, labor, tools, and incidentals necessary to complete the work.

Description	**Unit**
Aggregate Surface Course	Square Yard
Aggregate Surface Course	Ton

303 – RECYCLED ACP SURFACE/BASE COURSE

303.01 Description.

This work shall include furnishing, placing, shaping, scarifying, drying, and compacting a RAP surface/base course to provide a firm and stable surface or foundation in accordance with the lines, grades, and typical cross sections indicated in the Contract Documents.

303.02 Material Requirements.

(A) Recycled ACP.
Stockpiled recycled ACP shall consist of processed ACP free of soil, brick, vegetation, metal, or other contaminants. The maximum size of the processed material shall be two (2) inches or less in diameter.

(B) Emulsified Asphalt.
Emulsified asphalt for treating the material shall meet the requirements of CSS-1 or CSS-1h as defined by ASTM D2397, Standard Specification for Cationic Emulsified Asphalt.

303.03 Construction Requirements.

(A) Size Reduction Method #1 – Scarifying/Ripping.
Saw cut, in a manner acceptable to the Engineer, the perimeter of the area to receive recycled asphalt base course to the full depth of the pavement or as indicated in the Contract Documents. Scarify or rip the existing pavement using rubber-tired or tracked equipment equipped with a scarifier or ripper acceptable to the Engineer. Pulverize the scarified or ripped ACP material using equipment designed for the intended use. The maximum size of the pulverized material shall be two (2) inches or less in diameter.

(B) Size Reduction Method #2 – Cold Milling.
Saw cut, in a manner acceptable to the Engineer, the perimeter of the area to receive recycled asphalt base course to the full depth of the pavement or as indicated in the Contract Documents. Remove and pulverize the existing asphalt material using a rotary pulverizer or similar construction equipment designed for the intended use. The maximum size of the pulverized material shall be two (2) inches or less in diameter.

(C) Mixing (Treated Material Only).
When directed by the Contract Documents, thoroughly mix the recycled material and emulsified asphalt. The Contractor may mix the blend before, during, or after size reduction. Complete mixing before the emulsified asphalt breaks. Use equipment and mixing techniques acceptable to the Engineer.

The rate of application for emulsified asphalt shall be seven-tenths to nine-tenths (0.7 – 0.9) residual gallons per cubic foot of in-place asphalt material before scarifying/ripping or cold milling unless otherwise directed by the Engineer or Contract Documents. Do not apply the emulsified asphalt if the ambient temperature is less than fifty (50) degrees Fahrenheit.

(D) Placement, Compaction, and Finishing.

Spread and shape the pulverized material to the profile and cross section indicated in the Contract Documents. Windrow excess material outside the limits of the recycled pavement layer. Remove excess material upon completion of final grading. The excess material shall become the property of the Contractor unless otherwise indicated in the Contract Documents.

Place and compact the emulsified asphalt treated material in lifts not exceeding four (4) inches of compacted material. Compaction efforts shall begin on treated material when the emulsified asphalt starts to break. Before constructing additional lifts, allow the compacted lift of treated material to cure for a period determined by the Engineer based upon site and construction conditions.

Place and compact the untreated material in lifts not exceeding eight (8) inches of compacted material. Compaction efforts shall begin upon completion of shaping.

Select the number, size, and type of equipment that will achieve proper compaction. Compact treated and untreated material to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. Maintain the moisture content of the recycled ACP material in a range that facilitates achieving the required compaction.

Construct the recycled ACP course to a thickness within one-half (½) inch of the thickness indicated in the Contract Documents. The Engineer shall conduct thickness measurements after the Contractor has completed final grading. Correct all non-conforming areas in a manner acceptable to the Engineer. Scarify areas deficient in thickness to a minimum depth of three (3) inches before adding additional material.

The finished surface shall be free of ruts or other surface damage. The Contractor is responsible for protecting and maintaining the recycled ACP course. Repair any damaged areas at no additional cost to the City.

303.04 Measurement and Payment.

The Engineer shall measure recycled ACP surface course for payment by the total number of square yards of recycled ACP surface course constructed and accepted.

The Engineer shall measure emulsified asphalt treated recycled ACP surface course for payment by the total number of square yards of emulsified asphalt treated recycled ACP surface course constructed and accepted.

The Engineer shall measure recycled ACP base course for payment by the total number of square yards of recycled ACP base course constructed and accepted.

The Engineer shall measure emulsified asphalt treated recycled ACP base course for payment by the total number of square yards of emulsified asphalt treated recycled ACP base course constructed and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The contract price shall be full compensation for supplying and installation; for mixing; and for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Recycled ACP Surface Course	Square Yard
Recycled ACP Surface Course (Emulsified Asphalt Treated)	Square Yard
Recycled ACP Base Course	Square Yard
Recycled ACP Base Course (Emulsified Asphalt Treated)	Square Yard

THIS PAGE INTENTIONALLY LEFT BLANK

304 – RECYCLED PCC SURFACE/BASE COURSE

304.01 Description.

This work shall include furnishing, placing, shaping, scarifying, drying, watering, and compacting a recycled PCC surface/base course to provide a firm and stable surface or foundation in accordance with the lines, grades, and typical cross sections indicated in the Contract Documents.

304.02 Material Requirements.

(A) Recycled PCC.

Recycled PCC shall consist of processed PCC free of soil, vegetation, metal, or other deleterious contaminants and shall conform to the requirements of Table 304.01. The maximum size of the processed material shall be two (2) inches or less in diameter.

Table 304.01
Recycled PCC Physical Property Requirements

Physical Property	Acceptable Range
Sodium Sulfate Soundness, ASTM C88 (5 cycles)*	10.0% maximum loss
Magnesium Sulfate Soundness, ASTM C88 (5 cycles)*	15.0% maximum loss
Freeze-Thaw Soundness, AASHTO T103 (15 cycles)*	15.0% maximum loss
LA Abrasion, ASTM C131 and ASTM D535	40.0% maximum loss
Absorption, ASTM C127 and ASTM C128	3.0% maximum

*Only one of the three soundness requirements must be fulfilled.

Recycled PCC for base shall be free draining and shall meet the requirements of ASTM D2940, Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports and Table 301.01.

Recycled PCC surface material shall meet the requirements of ASTM D2940, Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports excluding any gradation requirements. The recycled PCC gradation shall conform to the requirements of Table 304.02.

Table 304.02
Recycled PCC Physical Property Requirements

Sieve Size	Allowable Percent Passing
1½”	100
#4	20-60
#10	0-30
#200	0-5

(B) Biaxial Geotextile Grid.

The biaxial geotextile grid shall be a type specifically manufactured for reinforcement applications. It shall consist of a network of integrally connected polymer tensile elements. The aperture size shall allow for mechanical interlock of the surrounding materials. The geogrid shall

have tensile and junction strength elements and shall be constructed of either a polyethylene, polypropylene or high-tenacity polyester that resists deformation due to dynamic forces. Table 304.03 illustrates the minimum average roll values (MARV) required for biaxial geotextile grid.

Table 304.03
Biaxial Geotextile Grid Requirements

Physical Property	Cross Machined Direction	Machined Direction
Tensile Strength at 2% Strain	450 lb/ft	280 lb/ft
Tensile Modulus	24,700 lb/ft	15,200 lb/ft
Ultimate Grid Junction Strength	490 lb/ft	
Flexural Stiffness	250,000 mg-cm	

Referenced Test Procedures:

- ASTM D4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
- GRI-GG2, Standard Test Method for Geogrid Junction Strength
- ASTM D1388, Standard Test Method for Stiffness of Fabrics – (Option A)

(C) Geotextile Fabric.

Geotextile fabric shall meet the requirements of AASHTO M288, Geotextile Specification for Highway Applications for the type and use indicated in the Contract Documents.

304.03 Construction Requirements.

(A) Method #1 – Remove and Process.

Saw cut, in a manner acceptable to the Engineer, the perimeter of the area to receive recycled PCC surface or base course to the full depth of the pavement or as indicated in the Contract Documents. Break and remove the PCC pavement in a manner acceptable to the Engineer. Determine the maximum size requirement for breaking the PCC before removal. Crush the removed PCC using equipment designed for the intended use. The maximum size of the pulverized material shall be two (2) inches or less in diameter. Avoid overloading the scalping screens. Cease crushing operations if, in the opinion of the Engineer, winds create excessive amounts of dust. Remove all reinforcing steel and wire mesh from the PCC before crushing.

Spread and shape the processed material to the profile and cross section indicated in the Contract Documents. Windrow excess material outside the limits of the recycled PCC surface or base course. Remove excess material upon completion of final grading. The excess material shall become the property of the Contractor unless otherwise indicated in the Contract Documents.

Place and compact the processed material in lifts not exceeding eight (8) inches of compacted material. Select the number, size, and type of equipment that will achieve proper compaction. Compact treated and untreated material to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. Maintain the moisture content of the crushed material in a range that facilitates achieving the required compaction.

Construct the recycled PCC surface or base course to a thickness within one-half (½) inch of the thickness indicated in the Contract Documents. The Engineer shall conduct thickness measurements after the Contractor has completed final grading. Correct all non-conforming areas in a manner acceptable to the Engineer. Scarify areas deficient in thickness to a minimum depth of three (3) inches before adding additional material.

The finished surface shall be free of ruts or other surface damage. The Contractor is responsible for protecting and maintaining the recycled PCC surface or base course. Repair any damaged areas at no additional cost to the City.

(B) Method #2 – Pulverize In-Place.

Saw cut, in a manner acceptable to the Engineer, the perimeter of the area to receive recycled PCC surface or base course to the full depth of the pavement or as indicated in the Contract Documents. Pulverize the material in-place using equipment designed for the intended use and capable of uniformly breaking the PCC pavement. The pulverizing process shall start at the outer edges of the pavement section and work towards the center of the pavement section. The maximum size of the pulverized material shall be four (4) inches or less in diameter. Do not operate any pulverizing equipment within fifty (50) feet of bridge abutment or other structures designated by the Contract Documents or the Engineer.

The Contractor may leave unexposed reinforcement in the pulverized PCC pavement. Remove all exposed reinforcement as directed by the Engineer.

Compact and seat the pulverized PCC using a vibratory steel drum roller. The vibratory steel drum roller shall pass over the pulverized PCC a minimum of four (4) times with the drums vibrating.

The finished surface shall be free of ruts or other surface damage. The Contractor is responsible for protecting and maintaining the recycled PCC surface or base course. Repair any damaged areas at no additional cost to the City.

(C) Geotextile Geogrid Installation.

Install geosynthetic geogrid in accordance with the manufacturer's recommendations. The recommendations shall include methods for temporarily securing uncovered segments, connection or splicing procedures to provide continuity, and overlap requirements. At a minimum, overlap adjacent strips of geogrid materials twelve (12) inches in all directions. Tracked construction equipment shall not pass over uncovered geosynthetic geogrid. Rubber-tired equipment working atop geogrid material shall operate at speeds less than ten (10) miles per hour and shall avoid any sudden stops or turns except in case of emergency. Repair any damage to uncovered geogrid or fabric at no additional cost to the City.

(D) Geotextile Fabric Installation.

Install geosynthetic geotextile fabric in accordance with the manufacturer's recommendations and AASHTO M288, Geotextile Specification for Highway Applications for the type and use indicated in the Contract Documents. The manufacturer's recommendations shall include methods for temporarily securing uncovered segments, connection or splicing procedures to provide continuity, and overlap requirements. Tracked construction equipment shall not pass over uncovered geosynthetic geotextile fabric. Rubber-tired equipment working atop geotextile fabric shall operate at speeds less than ten (10) miles per hour and shall avoid any sudden stops or turns except in case of emergency. Repair any damage to uncovered geotextile fabric at no additional cost to the City.

304.04 Measurement and Payment.

The Engineer shall measure recycled PCC surface course for payment by the number of square yards or tons of recycled PCC surface course constructed and accepted.

The Engineer shall measure recycled PCC base course for payment by the number of square yards or tons of recycled PCC base course constructed and accepted.

The Engineer shall measure geosynthetic geogrid for payment by the number of square yards of geogrid supplied, installed, and accepted excluding the overlapped quantity.

The Engineer shall measure geosynthetic geotextile fabric for payment by the number of square yards of geotextile fabric supplied, installed, and accepted excluding the overlapped quantity.

Removal and disposal of any reinforcement contained within the recycled material is subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation furnishing and placing, and for the cost for all materials, equipment, labor, tools, and incidentals necessary to complete the work.

Description	**Unit**
Recycled PCC Surface Course	Square Yard
Recycled PCC Surface Course	Ton
Recycled PCC Base Course	Square Yard
Recycled PCC Base Course	Ton
Geogrid	Square Yard
Geotextile Fabric	Square Yard

THIS PAGE INTENTIONALLY LEFT BLANK

400 FLEXIBLE PAVEMENTS

401 – ASPHALTIC CONCRETE PAVEMENT

401.01 Description.

This work shall include the construction of one or more courses of hot-mixed, hot laid, ACP on a prepared subgrade, subbase, base, or existing surface to the lines, grades, and typical cross sections indicated in the Contract Documents or as designated by the Engineer.

This work shall include the application of bituminous tack to previously prepared bases, or existing surfaces at locations indicated in the Contract Documents or as designated by the Engineer.

The work of asphaltic pavement repair shall include the removal and disposal of unstable or disintegrated base course, bituminous surfacing, armor coat, bituminous patching material, concrete, brick or cobblestone, or other pavement and constructing one or more courses of hot-mixed, hot laid, ACP in the areas from which unstable or disintegrated material has been removed. The work of pavement repair shall also include the correction of faulty subgrade conditions as directed by the Engineer. Concrete, brick, or cobblestone pavement repair will be limited to those areas where vertical displacement or failure has developed in the existing pavement. Irregularities and depressions in existing resurfaced pavements which do not involve the underlying concrete, brick or cobblestone, shall be corrected as a part of any resurfacing work and shall not be considered to be a part of the work of asphaltic concrete pavement repair.

The work of an ACP leveling or wedge course shall include thoroughly cleaning the existing surface and construction of one course of hot-mixed, hot laid, ACP of varied thickness in the cleaned areas generally to eliminate irregularities in the contour of existing roadways. Leveling of any surface irregularities in conjunction with resurfacing work shall be completed as part of the resurfacing work and shall not be considered as asphaltic concrete pavement repair.

401.02 Material Requirements.

(A) Bituminous Tack Coat.
Bituminous tack coat material shall meet the requirements of CSS-1 or CSS-1h as defined by ASTM D2397, Standard Specification for Cationic Emulsified Asphalt.

(B) Asphalt Release Agent.
Asphalt release agent shall consist of a detergent solution or other non-petroleum, non-solvent solution acceptable to the Engineer.

(C) Asphalt Binder.
Asphalt binder shall conform to the requirements of AASHTO MP-1, Standard Specification for Performance Graded Asphalt Binder, for the Performance Graded Binder indicated in Table 401.01.

Table 401.01
Performance Graded Binder Selection

	Pavement Layer	
Pavement Location	**Surface** (0" to 4" from surface)	**Base** (≥ 4" from surface)
Major Street	PG 70-28	PG 64-22*
Other Street	PG 70-28	PG 64-22*
Parking Lot/Parking Stalls	PG 70-28	PG 64-22*
Sidewalk/Bike Trail	PG 64-22*	PG 64-22*

* Contractor may substitute PG58-28 Binder for PG64-22 Binder only with written approval by the Engineer.

(D) Coarse Aggregate Source Properties.
Individual coarse aggregates shall conform to the requirements of ASTM D692, Standard Specification for Coarse Aggregate for Bituminous Paving Mixtures, and Table 3, Class 4S of ASTM C33, Specification for Concrete Aggregates, excluding any crushed particle or gradation requirements. Crush and grade individual coarse aggregates as needed to meet the required properties.

(E) Fine Aggregate Source Properties.
Individual fine aggregates shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete Aggregates, and ASTM D1073, Standard Specification for Fine Aggregate for Bituminous Paving Mixtures excluding any crushed particle or gradation requirements. Crush and grade individual fine aggregates as needed to meet the required properties.

(F) Mineral Fillers.
Individual mineral fillers added separate of coarse and fine aggregates shall meet the requirements of ASTM D242, Standard Specification for Mineral Filler for Bituminous Paving Mixtures.

(G) Anti-Stripping Agents.
The Engineer shall approve the type and application method of an anti-stripping agent. Follow the manufacturer's recommendations for adding to the mix.

(H) Reclaimed Asphalt Pavement (RAP).
RAP material shall consist entirely of ACP materials. Remove all concrete, brick, soil, or other contaminants. Process the RAP to have a consistent gradation and asphalt content in a manner acceptable to the Engineer. All processed material shall be less than two (2) inches in diameter before the Contractor introduces such material into the mixing chamber. Screen RAP material using a screen with a nominal two (2)

inch diameter opening immediately before introducing such material into the mixing chamber. Do not place any equipment on stockpiles of processed material. The Engineer reserves the right to reject a RAP source for any reason.

(I) Recycling Agents.
Recycling agents shall meet the requirements of ASTM D4552, Standard Practice for Classifying Hot-Mix Recycling Agents.

(J) ACP Proportioning and Required Properties.
Employ a nationally accredited laboratory meeting the requirements of ASTM D3666 to develop the ACP mix design. Mix designs developed more than nine (9) months before the start of paving are unacceptable. The Engineer may waive such requirement if the Contractor has produced the mix design within three (3) months of the start of paving and the production test data indicates that the requirements contained herein are satisfied. The ACP mixture shall meet the requirements of Tables 401.02, 401.03, and 401.04. Coarse aggregate is the total material retained on the #4 sieve. Fine aggregate is the total material passing the #4 sieve and retained on the #200 sieve. The Contractor is responsible for all costs associated with developing the ACP mix design.

At a minimum, Submit the following information on the proposed ACP mix design:

- Aggregate Sources, Proportions, Source Properties, and Individual and Combined Gradations;
- Individual Coarse and Fine Aggregate Specific Gravities for each component aggregate;
- Combined Aggregate Consensus Properties;
- RAP Content, Source, Gradation, and Binder Content;
- PG Binder Source, Grade, and Target Percentage; and the Manufacturer's Recommended Mixing and Compaction Temperatures;
- ACP Physical Properties at the varying Binder Contents used to develop the ACP mix design.

Table 401.02
Combined Aggregate Consensus Property Requirements*

Test Property	Mix Description				
	Major Street		All Other Pavement		
	CMM	FMM	CMR	FMR	Base
Coarse Aggregate - Fractured Faces – Two (2) or more Faces, %	80 Min.	80 Min.	80 Min.	80 Min.	70 Min.
Coarse Aggregate - Fractured Faces – One (1) or more Faces, %	85 Min.	85 Min.	85 Min.	85 Min.	75 Min.
Coarse Aggregate - Flat and/or Elongated Pieces – 5:1 Ratio, %	10 Max.	10 Max.	10 Max.	10 Max.	10 Max.
Fine Aggregate Angularity, %	45 Min.	45 Min.	40 Min.	40 Min.	40 Min.
Sand Equivalent Value	45 Min.	45 Min.	45 Min.	45 Min.	40 Min.

* Based on virgin materials only.

Table 401.03
ACP Physical Property Requirements

Test Property	Mix Description				
	Major Street		All Other Pavement		
	CMM	FMM	CMR	FMR	Base
Gyrations – $N_{initial}$	8	8	7	7	7
Gyrations – N_{design}	100	100	75	75	75
Gyrations – $N_{maximum}$	160	160	115	115	115
Compaction @ $N_{initial}$, %	≤ 89.0	≤ 89.0	≤ 90.5	≤ 90.5	≤ 91.5
Compaction @ N_{design}, %	95 to 97	95 to 97	95 to 97	95 to 97	95 to 97
Compaction @ $N_{maximum}$, %	≤ 98.0	≤ 98.0	≤ 98.0	≤ 98.0	≤ 98.0
PG Binder Content[1], % total mix	4.8 Min.	5.3 Min.	4.8 Min.	5.3 Min.	4.0 Min.
RAP, % of total mix	0 Max.	0 Max.	0 Max.	0 Max.	30 Max.
Mix Design Air Voids, %	4.0 – 5.5	4.0 – 5.5	4.0 – 5.5	4.0 – 5.5	4.0 – 5.5
Production Air Voids, %	3.0 – 5.0	3.0 – 5.0	3.0 – 5.0	3.0 – 5.0	3.0 – 6.0
Voids in Mineral Aggregate, %	14.0 Min.	15.0 Min.	14.0 Min.	15.0 Min.	13.0 Min.
Voids Filled with Asphalt, %	65 to 78	65 to 78	65 to 78	65 to 78	65 to 78
Film Thickness, Microns	9.0 Min.	9.0 Min.	9.0 Min.	9.0 Min.	8.0 min.
Filler To Effective Binder Ratio	0.6 - 1.6	0.6 - 1.6	0.6 - 1.6	0.6 - 1.6	0.6 - 1.8
Tensile Strength Ratio, %[2]	80 Min.	80 Min.	80 Min.	80 Min.	75 Min.

1 Engineer reserves the right to increase or decrease to satisfy film thickness requirements
2 Including Freeze-thaw procedure.

Table 401.04
Combined Aggregate Grading Requirements (% Passing)

Test Property	Mix Description				
	Major Street		All Other Pavement		
	CMM	FMM	CMR	FMR	Base
1" Sieve					100
¾" Sieve	100		100		90 to 100
½" Sieve	90 to 100	100	90 to 100	100	
⅜" Sieve		90-100		90 to 100	
#8 Sieve	28 to 58	32 to 67	28 to 58	32 to 67	23 to 49
#200 Sieve	2 to 10	2 to 10	2 to 10	2 to 10	2 to 8

Referenced Test Procedures.

- AASHTO MP-1, Performance Graded Asphalt Binder
- AASHTO MP-2, Specification for Superpave Volumetric Mix Design
- AASHTO PP-19, Practice for Volumetric Analysis of Compacted Hot-Mix Asphalt (HMA)
- AASHTO PP-28, Practice for Superpave Volumetric Design for Hot-Mix Asphalt (HMA)
- AASHTO T283, Resistance of Compacted Bituminous Mixture to Moisture Induced Damage
- Asphalt Institute Manual MS-2, Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types
- Asphalt Institute Manual SP-2, Superpave Level 1 Mix Design
- ASTM C33, Standard Specification for Concrete Aggregates
- ASTM C1252, Standard Test Method for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading) – Test Method A
- ASTM D8, Standard Terminology Relating to Materials for Roads and Pavements
- ASTM D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
- ASTM D2419, Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
- ASTM D3203, Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
- ASTM D3665, Practice for Random Sampling of Construction Materials
- ASTM D3666, Specification for Minimum Requirements of Agencies Testing and Inspecting Bituminous Paving Materials
- ASTM D4781, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
- ASTM D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
- ASTM D5444, Test Method for Mechanical Size Analysis of Extracted Aggregate
- ASTM D6307, Standard Test Method for Asphalt Content of Hot-Mix Asphalt by Ignition Method

401.03 Construction Requirements.

(A) Asphalt Mixing Plant.

The asphalt mixing plant shall meet the requirements of ASTM D995, Standard Specification for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures. For batch plants, the minimum dry mixing period shall be five (5) seconds and the minimum wet mixing period shall be twenty-five (25) seconds. All mixing plants shall have automatic controls for proportioning, timing, and discharge.

(B) Hauling Equipment.

Transport the ACP mixture in vehicles with tight, clean, smooth metal beds. The Contractor may lightly coat the bed with an approved asphalt release agent as allowed by the Engineer. Do not coat the bed with petroleum oils, solvents, or other material unacceptable to the Engineer. Cover all loads during adverse weather conditions, or when atmospheric temperatures are below sixty-five (65) degrees Fahrenheit, or when directed by the Engineer. Insulate the sides of the truck beds in a manner acceptable to the Engineer from October 15th to March 15th.

(C) Asphalt Paver.

Provide a self-propelled asphalt paver with a heated and vibrating screed to uniformly spread and finish the ACP mixture to the specified section width and thickness. The screed shall strike-off the surface without tearing, shoving, or gouging the ACP mixture. The asphalt paver shall be equipped with automatic screed controls capable of operating from a reference line or a ski from either or both sides of the paver. The screed shall maintain the transverse slope within one-tenth (0.1) percent of the required slope.

The screed and extensions shall be adjustable to the specified crown and mat thickness. The screed unit and any extensions shall have vibrators or tamper bars and heaters throughout its entire length. Control the temperature of the screed to prevent overheating or damage of the ACP material.

(D) Compaction Equipment.

Compact the ACP mixture using rollers capable of reversing without shoving or tearing the mixture. Vibratory rollers shall have separate energy and propulsion controls. Rubber-tired rollers shall have tire pressures as recommended by the manufacturer. A combination steel drum/rubber tire roller is unacceptable. Select the number, size, and type of equipment that will achieve proper compaction without displacing the mixture or crushing the aggregate. At a minimum, use one (1) roller to accomplish initial compaction and one (1) roller to accomplish final compaction and surface finishing at all times. Provide additional rollers as necessary to fulfill compaction requirements.

(E) Weather Limitations.

Place ACP mixtures on dry, unfrozen surfaces. Determine the minimum atmospheric temperature at which placement of ACP will be permitted in accordance with Table 401.05. The minimum placement temperature of ACP shall be at or above the manufacturer's recommended compaction temperature for the PG Binder used. The Engineer reserves the right to waive the temperature limitations. Waiving the temperature limitations does not relieve the Contractor of any other requirements stated in the Contract Documents.

Table 401.05
Temperature Limitations

Compacted Mat Thickness	Minimum Atmospheric Temperature, °F	Minimum Base Temperature, °F
3" or greater	40	35
1"-3"	40	40
<1"	50	45

(F) Surface Preparation.

Seal all cracks in the underlying pavement surface greater than one-fourth (¼) inch as directed by the Engineer. Apply a bituminous tack coat to all underlying pavement surfaces and the faces of all curbs, gutters, manholes, or other structures that will contact the ACP. Before applying a tack coat, Remove all dirt and loose or foreign materials from the underlying surface to a degree acceptable to the Engineer.

Apply a tack coat using a bituminous pressure distributor. The application rate shall be five-hundredths to fifteen-hundredths (0.05 – 0.15) residual gallons per square yard. Apply the tack coat in a manner that allows satisfactory penetration into the underlying surface. The surface temperature shall be equal to or above sixty (60) degrees Fahrenheit unless otherwise directed by the Engineer. Do not apply the tack coat during periods of precipitation.

Protect the surfaces of all appurtenances when the asphaltic material is applied. Repair any damages if the appurtenances are marred or spattered at no additional cost to the City.

Perform tack coat application in a manner that minimizes pickup or tracking on the tack coat materials. Limit the application to the area in which the Contractor can construct a subsequent course on that day using typical paving techniques. Post flagpersons, barricades, and warning signs in accordance with the City of Omaha Barricading Standards, Specifications, Methods, and Materials Manual or as directed by the Engineer.

(G) Mixing and Holding.

Heat and dry the aggregates to the appropriate mixing temperature before introducing the PG Binder. Regulate the heat applied to the aggregates to avoid damaging or contaminating the aggregate. Continuously supply heated PG Binder to the aggregate materials during mixing. Mixing shall continue until the PG Binder has uniformly coated at least ninety-five (95) percent of the aggregate materials when tested in accordance with ASTM D2489, Standard Test Method for Degree of Particle Coating of Bituminous-Aggregate Mixtures.

Store material to avoid segregation, excessive heat loss, or a reduced quality of mixture. Dispose of unsuitable mixture in a manner acceptable to the Engineer.

(H) Spreading and Finishing.

Schedule plant production, equipment, and delivery of material to the construction area in such a manner as to provide for a continuous operation. The Engineer must approve all haul routes over freshly placed material. Provide adequate artificial lighting acceptable to the Engineer during night placements.

Unless otherwise approved by the Engineer, Spread and finish the ACP mixture to specified grade and thickness using an asphalt paver(s). When multiple pavers are used, Space the pavers and deliver the ACP mix in a manner that provides for a continuous hot joint and is acceptable to the Engineer.

Upon arrival, the asphalt paver shall place the ACP mixture to the full width in a uniform layer. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a uniform slope. The minimum lift thickness for a non-leveling course shall be greater than or equal to three (3) times the nominal maximum aggregate size.

Manually place material in small patch areas and areas inaccessible to mechanical spreading and finishing equipment as allowed by the Engineer. The Contractor may use a material transfer vehicle (MTV) to deliver mix to the paver subject to approval by the Engineer. The MTV shall deliver material to the paver without causing segregation.

Pave intersections, driveways, or other non-mainline items upon encountering such items during mainline paving. Use the same rolling patterns as the mainline paving. All requirements of mainline paving apply to non-mainline ACP construction.

Operate the paver(s) at a speed that eliminates pulling or tearing of the ACP mat, avoids stop-and-go operations, and places the mix consistently with a surface acceptable to the Engineer. Use a self-contained grade reference system that automatically regulates the slope and grade of the screed unless otherwise approved by the Engineer. The self contained grade reference system shall consist of a sliding, rolling, or non contact electronic ski attachment device spanning at least thirty (30) feet, or sensors actuated from a previously established and approved grade or string line reference.

Unless otherwise approved by the Engineer, Construct the entire width of the preceding layer before any of the consecutive layers are constructed. Do not place the upper layer until the lower layer in the adjacent lane is completed.

Begin rolling operations before the temperature of the ACP material is below required compaction temperature for the PG Binder as specified in the ACP mix design. Pace the ACP placement operation to fulfill this requirement.

Saw cut all joints between old and new pavement in a manner acceptable to the Engineer. Cut the transverse joints back to full thickness pavement. Coat all vertical faces contacting ACP with a bituminous tack coat and fill the joint with enough ACP material to produce a joint with the desired, compacted thickness. Joints shall be cross-rolled wherever possible to produce a flush joint between the ACP and the adjacent material. Correct low joints by loosening the in-place ACP material, adding a sufficient amount of ACP material, and compacting in accordance with the requirements of this specification. Correct high joints by removing the excess material as needed during the breakdown rolling operation.

Locate the longitudinal and transverse joints to offset the joints of the previous underlying course. A minimum of a one (1) foot offset shall exist between the longitudinal joints and ten (10) foot offset between traverse joints of successive courses.

(I) Compacting and Finishing ACP.

Establish rolling patterns to compact the mixture uniformly and without undue displacement, cracking, or shoving. The number, weight, types of rollers, sequence of rolling operations, and compaction procedures shall be such that the required density and a satisfactory surface are consistently attained while the mixture is in a workable condition.

Operate the rollers at a slow, uniform pace. The rollers shall use scrapers or pads and water or an approved asphalt release agent to prevent adhesion of the mixture to the roller. Do not use excessive amounts of water/release agent as determined by the Engineer. In areas not accessible to a roller, Compact the mixture to the required density using hand tampers or other suitable equipment.

Immediately repair any displaced or defective ACP by removing and replacing it with fresh, hot ACP material to the required thickness. Skin patching is unacceptable as a repair technique. Rolling operations shall continue until the Contractor achieves the required compaction and the surface is uniform in texture and true to grade and cross section.

Compact the ACP to the minimum percentage of maximum theoretical density (MTD) indicated in Table 401.06. The MTD shall be determined in accordance with ASTM D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures. Measure joint compaction by randomly sampling the constructed pavement located on and within three (3) inches of a construction joint.

Table 401.06
ACP Compaction Requirements

Pavement Layer	Mat Compaction Requirement (% of MTD)	Joint Compaction Requirement (% of MTD)
Surface Layers (≤4" below final surface elevation)	92% Minimum	90% Minimum
Base Layers (>4" below final surface elevation)	90% Minimum	90% Minimum

In areas inaccessible to standard rolling equipment, compact ACP to the required density in a manner acceptable to the Engineer. After final compaction, verify that the ACP surface is smooth and true to the established crown and grade.

A wedge course of less than one (1) inch is not subject to a percentage compaction requirement. Compact such a lift to the satisfaction of the Engineer.

The Contractor is responsible for monitoring compaction throughout the rolling process using a nuclear densitometer. Establish a rolling pattern that fulfills the compaction requirements defined in Table 401.06. Perform testing as necessary, in accordance with ASTM D2950, Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Method.. The Engineer shall not use the results of such testing as a measure of acceptance or rejection of the ACP constructed.

The maximum allowable deviation from the specified elevation is minus zero (-0), plus one-half (+½) inch provided the deviation does not alter the designed drainage pattern. The finished surface shall be smooth and free of bumps or depressions greater than one-fourth (¼) inch when tested with a ten (10) foot straight edge. Repair non-conforming areas by removing a sufficient amount of material to allow for the construction of a lift of ACP three (3) times the nominal maximum aggregate size. Remove high spots by grinding using a diamond tipped grinding wheel or other equipment acceptable to the Engineer. Perform all repairs at no additional expense to the City.

401.04 Measurement and Payment.

Unless otherwise stated in the Contract Documents, anti-stripping agents/measures/techniques, surface preparation, including crack sealing and/or bituminous tack coat application, compaction monitoring during placement operations, flagpersons, barricades, and warning signs are subsidiary to items for which the Contract provides direct payment. All costs associated with developing the ACP mix design are subsidiary to items for which the Contract provides direct payment.

Unless otherwise indicated in the Contract Documents, the Contractor shall be assessed pay deductions for failure to meet the requirements previously outlined. The total pay factor is the product of the individual pay factors for the measured properties determined in accordance with Table 401.07. If any pay factor for the measured property indicates rejected material, remove and replace such material at no additional cost to the City. The Engineer reserves the right to accept rejected material at a total pay factor of fifty (50) percent.

The Engineer shall determine the pay factor on a lift-by-lift basis. Allow the Engineer sufficient time to determine the pay factor of any underlying material before constructing the next lift of ACP. If the project consists of multiple streets or locations along the same street(s), the Engineer shall determine a separate, total pay factor for each individual location or continuous segment of a street. The Engineer shall base the pay factor determination using the average of a minimum of three (3) samples. The Engineer reserves the right to combine locations having less than three (3) samples with the next location constructed.

The Contractor may use individual pay factors greater than one (1.0) to offset individual pay factors less than one (1.0). In no case shall the total pay factor exceed one (1.0). Consider any total pay factor greater than one (1.0) to be one (1.0) unless otherwise indicated in the Contract Documents.

The Contractor may request one (1) re-sampling of individual pavement cores for improving the total pay factor for mat or joint density. The Engineer shall combine the compaction values obtained from the re-sampled cores with those of the original cores and compute a new total average.

The Engineer shall use only surface or base mat cores to determine the ACP thickness.

The Engineer shall omit individual pay factors if such items are not required.

The Engineer shall compute the total pay factor as follows:

Table 401.07
ACP Pay Factor Determination

Measured Property	Average Measured Value[1,4]		Pay Factor
Surface Compaction, % (0" to 4" from finished elevation)	≥ 93.5		1.03
	≥ 92.0		1.00
	91.5 to 91.9		0.95
	91.0 to 91.4		0.90
	90.0 to 90.9		0.80
	< 90.0		Reject
Base Compaction, % (> 4" from finished elevation)	≥ 92		1.03
	≥ 90.0		1.00
	89.5 to 89.9		0.95
	88.5 to 89.4		0.85
	87.5 to 88.4		0.75
	< 87.5		Reject
Joint Compaction, % (all depths)	≥ 91		1.05
	≥ 90.0		1.00
	89.5 to 89.9		0.95
	88.5 to 89.4		0.85
	87.5 to 88.4		0.75
	< 87.5		Reject
Deviation below Minimum Film Thickness, microns	≥ 1.0 above minimum		1.05
	0.0 to -0.5		1.00
	-0.6 to -1.0		0.95
	-1.1 to -1.5		0.85
	-1.6 to 2.0		0.75
	> -2.0		Reject
Air Voids, % (all depths)	3.75 – 4.25		1.05
	3.00-3.74	4.26-5.0	1.00
	2.25-2.99	5.01-5.75	0.95
	1.75-2.24	5.76-6.25	0.85
	1.25-1.74	6.26-6.75	0.75
	< 1.25	> 6.75	Reject
Deviation from Design Thickness[2,3], inches	0.0 to 0.25		1.00
	0.26 to 0.50		0.90
	0.51 to 0.75		0.80
	0.76 to 1.00		0.70
	> 1.00		Reject

1 – Average value for specific mix type placed on a specific roadway or project.
2 – Absolute Value of the difference from the thickness required by the Contract Documents. For payment by Method #1, the Engineer reserves the right to enforce this individual pay factor if the average measured thickness is less than the design thickness. For payment by Method #2, omit this individual pay factor if the average measured thickness is greater than the design thickness.
3 – For levelling courses or sinlge-lift resurfacing/overlay projects, omit this individual Pay Factor unless otherwise indicated in the Contract Documents.
4 – Total Pay Factor shall not exceed one (1.00) unless otherwise indicated in the Contract Documents.

(A) Method #1 – Per Ton Measurement.

The Engineer shall measure ACP as a single unit defined as the pay factor multiplied by the number of tons of ACP constructed and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The contract price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidental necessary to complete the work.

Description	Unit
Construct Asphalt Surface Course, Type ____ (PG __–__)	Ton
Construct Asphalt Base Course (PG __–__)	Ton
Construct Asphalt Wedge Course, Type ____ (PG __–__)	Ton
Asphaltic Concrete For Pavement Repair – Large Area, Type ____ (PG __–__)	Ton
Asphaltic Concrete For Pavement Repair – Small Area, Type ____ (PG __–__)	Ton
Asphalt Driveway, Type ___ (PG __–__)	Ton
Asphalt Sidewalk, Type ___ (PG __–__)	Ton

(B) Method #2 – Per Square Yard Measurement.

The Engineer shall measure asphaltic concrete pavement as a single unit defined as the pay factor multiplied by the number of square yards of each thickness of asphaltic concrete pavement constructed and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The contract price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidental necessary to complete the work.

Description	Unit
Construct ___" Asphalt Surface Course, Type ____ (PG __–__)	Square Yard
Construct ___" Asphalt Base Course (PG __–__)	Square Yard
Construct Asphalt Wedge Course (PG __–__)	Square Yard
Asphaltic Concrete For Pavement Repair – Large Area, Type ____ (PG __–__)	Square Yard
Asphaltic Concrete For Pavement Repair – Small Area, Type ____ (PG __–__)	Square Yard
Asphalt Driveway, Type ___ (PG __–__)	Square Yard
Asphalt Sidewalk, Type ___ (PG __–__)	Square Yard

THIS PAGE INTENTIONALLY LEFT BLANK

402 – ASPHALTIC CONCRETE CURB

402.01 Description.

Asphaltic concrete curb work shall consist of the construction of curbs of asphaltic concrete on previously prepared bases or existing pavements in accordance with these specifications and in the shape and dimensions as shown in the plans and special provisions or as directed by the Engineer.

This work shall include the application of bituminous tack to previously prepared bases, or existing surfaces at locations indicated in the Contract Documents or as designated by the Engineer.

402.02 Material Requirements.

(A) Bituminous Tack Coat.
Bituminous tack coat material shall meet the requirements of CSS-1 or CSS-1h as defined by ASTM D2397, Standard Specification for Cationic Emulsified Asphalt.

(B) Asphalt Release Agent.
Asphalt release agent shall consist of a detergent solution or other non-petroleum, non-solvent solution acceptable to the Engineer.

(C) Asphalt Binder.
Asphalt binder shall conform to the requirements of AASHTO MP-1, Standard Specification for Performance Graded Asphalt Binder, for a PG 58-28 or PG 64-22 Binder.

(D) Coarse Aggregate Materials.
Individual coarse aggregates shall conform to the requirements of ASTM D692, Standard Specification for Coarse Aggregate for Bituminous Paving Mixtures, and Table 3, Class 4S of ASTM C33, Specification for Concrete Aggregates, excluding any crushed particles or gradation requirements. Crush and grade individual coarse aggregates as needed to meet the required properties.

(E) Fine Aggregate Materials.
Individual fine aggregates shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete Aggregates, and ASTM D1073, Standard Specification for Fine Aggregate for Bituminous Paving Mixtures excluding any crushed particles or gradation requirements. Crush and grade individual fine aggregates as needed to meet the required properties.

(F) Mineral Fillers.
Individual mineral fillers, added separate of coarse and fine aggregates, shall meet the requirements of ASTM D242, Standard Specification for Mineral Filler for Bituminous Paving Mixtures.

(G) Anti-Stripping Agents.
The Engineer shall approve the type and application method of an anti-stripping agent. Follow the manufacturer's recommendations for adding to the mix.

(H) Reclaimed Asphalt Pavement (RAP).
RAP material shall consist entirely of ACP materials. Remove all concrete, brick, soil, or other contaminants. Process the RAP to have a consistent gradation and asphalt content in a manner acceptable to the Engineer. All processed material shall be less than two (2) inches in diameter before the Contractor introduces such material into the mixing chamber. Screen RAP material using a screen with a nominal two (2) inch diameter opening immediately before introducing such material into the mixing chamber. Do not place any equipment on stockpiles of processed material. The Engineer reserves the right to reject a RAP source for any reason.

(I) ACP Proportioning and Required Properties.
The ACP mixture shall meet the requirements of Table 402.01 and Table 402.02. Coarse aggregate is the total material retained on the #4 sieve. Fine aggregate is the total material passing the #4 sieve and retained on the #200 sieve.

Table 402.01
Physical Property Requirements

Physical Property	Acceptable Limits
Asphalt Binder Content, % of Total Mix	6.0-9.0
Production Air Voids, %	3.0 – 8.0
Stability, lbs.	1500 Min.
Tensile Strength Ratio (TSR), %	75 Min.
RAP Content, % of Total Aggregate	50 Max.
Combined Fine Aggregate Angularity	40% Min.

Table 402.02
Gradation Requirements

Sieve Size	Acceptable Limits (% Passing)
¾"	100
½"	85-100
#4	65-80
#8	50-65
#50	18-30
#200	5-15

The Contractor may use alternative gradation requirements with a history of satisfactory performance as allowed by the Engineer.

Referenced Test Procedures.
- AASHTO T245, Resistance to Plastic Flow Using the Marshall Apparatus
- ASTM C33, Standard Specification for Concrete Aggregates

- ASTM C1252, Standard Test Method for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading) – Test Method A
- ASTM D8, Standard Terminology Relating to Materials for Roads and Pavements
- ASTM D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
- ASTM D3203, Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
- ASTM D3665, Practice for Random Sampling of Construction Materials
- ASTM D4781, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
- ASTM D4867, Standard Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures
- ASTM D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
- ASTM D5444, Test Method for Mechanical Size Analysis of Extracted Aggregate
- ASTM D6307, Standard Test Method for Asphalt Content of Hot-Mix Asphalt by Ignition Method

402.03 Construction Requirements.

(A) Asphalt Mixing Plant.

The asphalt mixing plant shall meet the requirements of ASTM D995, Standard Specification for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures. For batch plants, the minimum dry mixing period shall be five (5) seconds and the minimum wet mixing period shall be twenty-five (25) seconds. All mixing plants shall have automatic controls for proportioning, timing, and discharge.

(B) Hauling Equipment.

Transport the ACP mixture in vehicles with tight, clean, smooth metal beds. The Contractor may lightly coat the bed with an approved asphalt release agent as allowed by the Engineer. Do not coat the bed with petroleum oils, solvents, or other material unacceptable to the Engineer. Cover all loads during adverse weather conditions, or when atmospheric temperatures are below sixty (65) degrees Fahrenheit, or when directed by the Engineer. Insulate the sides of the truck beds in a manner acceptable to the Engineer from October 15th to March 15th.

(C) Asphalt Curbing Machine.

Provide a self-powered curbing machine capable of extruding and compacting the asphalt mixture. The curbing machine shall construct curb, free of honeycombs, to the line, grade, and cross-section indicated in the Contract Documents.

(D) Weather Limitations.

Place ACP curb on dry, unfrozen surfaces. Determine the minimum atmospheric temperature at which placement of ACP will be permitted in accordance with Table 402.03. The minimum placement temperature of ACP shall be at or above the manufacturer's recommended compaction temperature for the PG Binder used. The Engineer reserves the right to waive the temperature limitations. Waiving the temperature limitations does not relieve the Contractor of any other requirements stated in the Contract Documents.

Table 402.03
Temperature Limitations

Minimum Atmospheric Temperature, °F	Minimum Base Temperature, °F
40	35
40	40
50	45

(E) Surface Preparation.

Seal all cracks in the underlying pavement surface as directed by the Engineer. Apply a bituminous tack coat to all underlying pavement surfaces and the faces of all curbs, gutters, manholes, or other structures that will contact the ACP. Before applying a tack coat, Remove all dirt and loose or foreign materials from the underlying surface to the satisfaction of the Engineer.

Apply a tack coat using a bituminous pressure distributor. The application rate shall be five-hundredths to fifteen-hundredths (0.05 – 0.15) residual gallons per square yard. Apply the tack coat in a manner that allows satisfactory penetration into the underlying surface. The atmospheric temperature shall be equal to or above sixty (60) degrees Fahrenheit unless otherwise directed by the Engineer.

Protect the surfaces of all appurtenances when the asphaltic material is applied. Repair any damages if the appurtenances are marred or spattered at no additional cost to the City.

Perform tack coat application in a manner that minimizes pickup or tracking on the tack coat materials. Limit the application to the area in which the Contractor can construct the ACP curb on that day using typical paving techniques. Post flagpersons, barricades, and warning signs as directed by the Engineer.

(F) Mixing and Holding.

Heat and dry the aggregates to the appropriate mixing temperature before introducing the PG Binder. Regulate the heat applied to the aggregates to avoid damaging or contaminating the aggregate. Continuously supply heated PG Binder to the aggregate materials during mixing. Mixing shall continue until the PG Binder has uniformly coated at least ninety-five (95) percent of the aggregate materials when tested in accordance with ASTM D2489, Standard Test

Method for Degree of Particle Coating of Bituminous-Aggregate Mixtures.

Store material to avoid segregation, excessive heat loss, or a reduced quality of mixture. Dispose or unsuitable mixture in a manner acceptable to the Engineer.

(G) Curb Construction.

Construct the back edge of the ACP curb a minimum of two (2) inches in from the pavement edge or as indicated in the Contract Documents. Unless otherwise approved by the Engineer, Spread and finish the ACP mixture to specified grade and thickness using the curbing machine. Manually place material in areas inaccessible to the curbing machine. Protect the newly constructed curb from traffic in a manner acceptable to the Engineer until the heat of the asphalt mixture has dissipated.

Saw cut the joints between old and new curb in a manner acceptable to the Engineer. Coat all vertical faces contacting the ACP curb with a bituminous tack coat. Protect the existing curb from damage. Repair any damage at no cost to the City.

Operate the curbing machine at a consistent speed that avoids stop-and-go operations. Schedule plant production, equipment, and delivery of material to the construction area in such a manner as to provide for a continuous operation. Provide adequate artificial lighting acceptable to the Engineer during night placements.

The finished top of curb shall not vary from the design elevation by more than one-fourth (¼) inch. The finished curb face shall be smooth and free of bumps or depressions greater than one-fourth (¼) inch when tested with a ten (10) foot straight edge. Repair low, depressed, or defective areas by removing a sufficient amount of material to allow for the construction of a lift of ACP three (3) times the nominal maximum aggregate size. Remove high spots by grinding using a diamond tipped grinding wheel or other equipment acceptable to the Engineer. Perform all repairs at no additional expense to the City.

Backfill all new ACP curb with non-plastic or low plasticity materials.

402.04 Measurement and Payment.

The Engineer shall measure the ACP curb by the linear foot along the front face of the curb constructed and accepted.

Unless otherwise stated in the Contract Documents, surface preparation, including crack sealing and/or bituminous tack coat application, flagpersons, barricades, and warning signs are subsidiary to items for which the Contract provides direct payment. All costs associated with developing

the ACP mix design are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The contract price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidental necessary to complete the work.

Description	**Unit**
ACP Curb	Linear Foot

403 – PAVEMENT FABRIC REINFORCEMENT

403.01 Description.

This work includes the supplying and installation of pavement fabric reinforcement in ACP generally for preventing or minimizing reflective cracking from underlying pavements.

403.02 Material Requirements.

Pavement fabric reinforcement shall meet the requirements of AASHTO M288, Geotextile Specification for Highway Applications, Section 9. Store pavement fabrics in a cool, dry location free from dust.

403.03 Construction Requirements.

Pavement fabric installation shall be in accordance with the manufacturer's instructions and AASHTO M288, Geotextile Specification for Highway Applications, Appendix A, Section A6. Do not allow non-emergency traffic on the pavement fabric unless otherwise indicated in the Contract Documents. Protect pavement fabric during construction of subsequent pavement layers. Remove and replace any pavement fabric sections damaged or displaced during construction of subsequent layers.

403.04 Measurement and Payment.

The Engineer shall measure pavement fabric reinforcement by the square foot or square yard installed and accepted.

Accomplish removal and replacement of damaged or displaced pavement fabric at no additional cost to the City.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The contract price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidental necessary to complete the work.

Description	Unit
Pavement Reinforcement Fabric	Square Foot
Pavement Reinforcement Fabric	Square Yard

THIS PAGE INTENTIONALLY LEFT BLANK

404 – BITUMINOUS SURFACE TREATMENT

404.01 Description.

This work shall include the supplying and application of a bituminous material on previously prepared pavement surface, with a covering of mineral aggregate at the locations indicated in the Contract Documents or as directed by the Engineer.

404.02 Material Requirements.

(A) Cover Aggregate.
Cover aggregate shall comply with the requirements for aggregate standard size number 9 as defined by ASTM D448, Standard Classification for Sizes of Aggregate for Road and Bridge Construction and ASTM D1139, Standard Specification for Aggregate for Single or Multiple Bituminous Surface Treatments.

(B) Emulsified Asphalt.
Emulsified asphalt shall conform to the requirements for RS-1, RS-2, HFRS-2, CRS-1, or CRS-2 as defined by ASTM D977, Standard Specification for Emulsified Asphalt and ASTM D2397, Standard Specification for Cationic Emulsified Asphalt.

(C) Cutback Asphalt.
Cutback asphalt shall conform to the requirements for MC-800, MC-3000, RC-250, RC-800, or RC-3000 as defined by ASTM D2027, Standard Specification for Cutback Asphalt (Medium-Curing Type) and ASTM D2028, Standard Specification for Cutback Asphalt (Rapid-Curing Type).

404.03 Construction Requirements.

(A) Surface Preparation.
Seal all cracks greater than one-fourth (¼) inch and repair damaged areas in the underlying pavement surface as directed by the Engineer. Clean the surface thoroughly to the satisfaction of the Engineer.

(B) Application of the Bitumen.
Apply either emulsified asphalt or cutback asphalt using a bituminous pressure distributor at the rate determined in accordance with ASTM D1369, Standard Practice for Quantities of Materials for Bituminous Surface Treatments. Calibrate the bituminous pressure distributor in accordance with ASTM D2995, Standard Practice for Determining Application Rate of Bituminous Distributors.

Apply the bitumen when the atmospheric temperature is equal to or above (50) degrees Fahrenheit unless otherwise approved by the

Engineer. Do not apply the bitumen during periods of precipitation. Do not overlap at the end junction of two successive applications.

Protect the surfaces of all appurtenances when the bitumen is applied. Repair any damages if the appurtenances are marred or spattered at no additional cost to the City. Perform application of the bitumen in a manner that minimizes pickup or tracking. Post flagpersons, barricades, and warning signs as directed by the Engineer. Such work is subsidiary to the bituminous surface treatment.

(C) Application of the Cover Aggregate.

Apply the cover aggregate immediately after the application of the asphaltic material at the rate determined in accordance with ASTM D1369, Standard Practice for Quantities of Materials for Bituminous Surface Treatments. Uniformly spread the cover aggregate using a mechanical aggregate spreading device calibrated in accordance with ASTM D5624, Standard Test Method for Determining the Transverse – Aggregate Spread Rate for Surface Treatment Applications and acceptable to the Engineer.

(D) Rolling and Maintenance of the Bituminous Surface Treatment.

Roll the surface immediately after spreading the cover aggregate using a pneumatic-tired roller with a minimum gross weight of twelve (12) tons. Pneumatic-tired rollers shall have tire pressures as recommended by the manufacturer. At a minimum, Keep two (2) rollers on-site and available for use at all times.

The roller speed shall be less than five (5) miles per hour. The roller shall pass over each portion of the bituminous surface treatment a minimum of four (4) times unless otherwise instructed by the Engineer. The first pass shall occur within five (5) minutes of spreading the aggregate. Complete all passes within thirty (30) minutes of spreading the aggregate.

Dispose of all loose cover aggregate within forty-eight (48) hours following the bituminous surface treatment.

404.04 Measurement and Payment.

The Engineer shall measure the bituminous surface treatment by the square yard of area receiving the bituminous surface treatment and accepted.

Unless otherwise stated in the Contract Documents, surface preparation, including crack sealing and/or repair of damaged areas, flagpersons, barricades, and warning signs are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The contract price shall be full compensation for

furnishing all labor, materials, equipment, tools, and incidental necessary to complete the work.

Description	**Unit**
Bituminous Surface Treatment	Square Yard

THIS PAGE INTENTIONALLY LEFT BLANK

405 – FOG SEAL

405.01 Description.

This work shall include the supplying and application of a bituminous material on previously prepared ACP surface aggregate at the locations indicated in the Contract Documents or as directed by the Engineer.

405.02 Material Requirements.

Emulsified asphalt shall conform to the requirements for MS-1, HFMS-1, SS-1, SS-1h, CSS-1, or CSS-1h as defined by ASTM D977, Standard Specification for Emulsified Asphalt and ASTM D2397, Standard Specification for Cationic Emulsified Asphalt.

405.03 Construction Requirements.

(A) Surface Preparation.
Seal all cracks greater than one-fourth (¼) inch and repair damaged areas in the underlying pavement surface as directed by the Engineer. Clean the surface thoroughly to the satisfaction of the Engineer. Unless otherwise indicated in the Contract Documents, crack sealing and/or repair of damaged areas is incidental to the bituminous surface treatment.

(B) Application of the Fog Seal.
Apply the emulsified asphalt using a bituminous pressure distributor calibrated in accordance with ASTM D2995, Standard Practice for Determining Application Rate of Bituminous Distributors. The application rate shall be fifteen-hundredths to twenty-five hundredths (0.15 – 0.25) of a gallon per square yard.

Apply the bitumen when the atmospheric temperature is equal to or above fifty (50) degrees Fahrenheit unless otherwise approved by the Engineer. Do not apply the bitumen during periods of precipitation. Do not overlap at the end junction of two successive applications.

Protect the surfaces of all appurtenances when the bitumen is applied. Repair any damages if the appurtenances are marred or spattered at no additional cost to the City. Perform application of the bitumen in a manner that minimizes pickup or tracking. Post flagpersons, barricades, and warning signs as directed by the Engineer.

405.04 Measurement and Payment.

The Engineer shall measure the fog seal by the number of square yards of fog seal applied and accepted.

Flagpersons, barricades, and warning signs are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The contract price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidental necessary to complete the work.

Description	**Unit**
Fog Seal	Square Yard

406 – SLURRY SEAL

406.01 Description.

This work shall include the supplying and application of an aggregate-bituminous mixture on a previously prepared surface at the locations indicated in the Contract Documents or as directed by the Engineer.

406.02 Material Requirements.

The slurry seal mix design shall meet the requirements for Type 3 Slurry Seal as defined by ASTM D3910, Standard Practices for Design, Testing, and Construction of Slurry Seal except as modified herein. Fine aggregate shall be crushed limestone, quartzite, chat, dolomite, or combination thereof. It shall meet the requirements for fine aggregate as defined by ASTM C33, Specification for Concrete Aggregates, and ASTM D1073, Standard Specification for Fine Aggregate for Bituminous Paving Mixtures excluding any gradation requirements.

406.03 Construction Requirements.

(A) Surface Preparation.
Seal all cracks greater than one-fourth (¼) inch and repair damaged areas in the underlying pavement surface as directed by the Engineer. Clean the surface thoroughly to the satisfaction of the Engineer. Unless otherwise indicated in the Contract Documents, crack sealing and/or repair of damaged areas is incidental to slurry seal construction.

(B) Application of the Fog Seal.
Construct the slurry seal in accordance with ASTM D3910, Standard Practices for Design, Testing, and Construction of Slurry Seal.

406.04 Measurement and Payment.

The Engineer shall measure the slurry seal by the number of square yards of prepared surface receiving the slurry seal and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The contract price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidental necessary to complete the work.

Description	Unit
Slurry Seal	Square Yard

THIS PAGE INTENTIONALLY LEFT BLANK

500 RIGID PAVEMENT

501 – PCC PAVEMENT

501.01 Description.

The work includes construction of Portland Cement Concrete (PCC) pavement, PCC Overlay, PCC Base Course, PCC driveway, PCC header, PCC pavement beam, or PCC pavement repair constructed on prepared subgrade, base, or subbase materials in accordance with the specifications, lines, grades, and cross sections indicated in the Contract Documents or established by the Engineer. The work includes removal or preparation of the existing pavement or materials and construction of PCC pavement at the locations indicated in the Contract Documents or designated by the Engineer.

In general, conduct PCC pavement repair where vertical displacement or failure in the existing PCC pavement has developed. Repair areas may require removal and replacement of the curb. Construct PCC pavement repairs on the prepared subgrade, base, or subbase in accordance with the requirements of the Contract Documents. Shape PCC pavement repairs to be rectangular having edges parallel and perpendicular to the existing joint pattern. Generally, define small PCC pavement repairs as areas consisting of individual sections of pavement with an area less than or equal to sixty (60) square yards or areas having one dimension six (6) feet or less. Generally, define large PCC pavement repairs as all areas excluded by the definition of a small PCC pavement repair. Generally, the thickness of the PCC pavement repair shall equal the existing pavement thickness plus an additional two (2) inches for a small repair and the existing pavement thickness for a large repair. The minimum thickness of a small PCC pavement repair shall be nine (9) inches on residential streets and eleven (11) inches on major streets. The minimum thickness of a large PCC pavement repair shall be seven (7) inches on residential streets and nine (9) inches on major streets.

501.02 Material Requirements.

(A) Portland Cement for PCC.

Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 2 (Maximum Equivalent Alkalies requirements only) and Table 3. Do not use blended hydraulic cements without prior approval of the Engineer. Blended hydraulic cements shall conform to the requirements of ASTM C595, Standard Specification for Blended Hydraulic Cements.

(B) Aggregate for PCC.

Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(C) Water for PCC.

All water used in the PCC mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(D) Admixtures for PCC.

Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete, ASTM C1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete, or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC. Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(E) Coloring Agent for PCC.

Coloring agent shall comply with the requirements of ASTM C979, Pigments for Integrally Colored Concrete. Add coloring agent in accordance with the manufacturer’s recommendations. The maximum allowable dosage for a coloring agent is ten (10) percent of the total weight of cementitious materials.

(F) PCC Stain for PCC.

PCC stain shall be a waterborne, acrylic-based stain designed for the intended use and acceptable to the Engineer.

(G) Pre-molded Joint Filler.

Pre-molded joint filler for expansion joints shall conform to the requirements of ASTM D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). Neatly punch holes to admit the dowels where indicated in the Contract Documents. The diameter of the holes shall not exceed one-half (½) inch greater than the bar diameter. When more than one piece is required for a joint, securely fasten the abutting ends by stapling or other positive fastening means satisfactory to the Engineer.

(H) Pressure Relief Joint Filler.

Pressure relief joint filler shall conform to the requirements of ASTM D3204, Standard Specification for Preformed Cellular Plastic Joint Fillers for Relieving Pressure.

(I) Joint Sealant.

Joint sealant shall be a polyurethane, silicone, or bitumastic liquid material intended for use as a PCC pavement sealant and shall conform to the requirements of C920, Standard Specification for Elastomeric Joint Sealants; ASTM D5893, Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements; or ASTM D6690, Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements. For colored PCC applications, color-match the sealing compound to the colored PCC. The Engineer shall approve the color match before application begins.

(J) Reinforcement for PCC.

Welded wire fabric shall conform to the requirements of ASTM A185, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement. Welded bar mats shall conform to the requirements of ASTM A704, Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement. Tie bars shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60, rail steel bars for tie bars bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement. Keep reinforcing metal clean and free of rust or foreign material. Protect reinforcing materials from weather until placement. Supply and store welded wire sheets and welded bar mats in flat sheets.

(K) Curing Materials for PCC.

Curing materials shall be liquid, membrane forming compounds, polyethylene sheeting, or an asphalt emulsion. Liquid, membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene sheeting for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete. Asphalt emulsion for curing low strength concrete shall conform to the requirements for Type SS-1h as defined by ASTM D977, Standard Specification for Emulsified Asphalt.

(L) PCC Mix Proportioning and Required Properties.

Proportion PCC mixtures to meet the requirements of Table 501.01. Do not use fly ash in the PCC mixture. Manufacture the PCC in accordance with ASTM C94, Standard Specification for Ready-Mixed Concrete.

Table 501.01
PCC Properties

Mix Type	L6	L65	L75	L85
Portland Cement Content, lbs. per cu. yd.	564 min.	611 min.	705 min.	799 min.
Coarse Aggregate, % of Total Aggregate	30±3	30±3	30±3	30±3
Fine Aggregate, % of Total Aggregate	70±3	70±3	70±3	70±3
Maximum Water Cement Ratio	0.45	0.45	0.45	0.45
Minimum 28-Day Compressive Strength, psi	3500	4000	4500	4500
Air Content, %	6.5±1.0	6.5±1.0	6.5±1.0	6.5±1.0
Slump (Formed Pavement), inches	2.5±1.5	2.5±1.5	2.5±1.5	2.5±1.5
Slump (Slip-form Pavement), inches	1.5±1.5	1.5±1.5	1.5±1.5	1.5±1.5
PCC Temperature during placement, °F	70±20	70±20	70±20	70±20

Referenced Test Procedures:

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

501.03 Construction Requirements.

(A) Equipment.

Provide all equipment, labor, and tools necessary to perform the work to the satisfaction of the Engineer. The National Ready Mixed Concrete Association shall certify that the PCC production facilities

and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

The production facility shall provide the batch information for each load of PCC delivered to the site. The batch information shall accompany each load delivered to the site. At a minimum, the batch information shall include the component materials, the actual batch weights and target batch weights of component materials, free moisture content of aggregates, water cement ratio of batch, and amount of additional water added at production facility after batching.

Paving machines shall be self-propelled and capable of spreading and striking off the necessary quantity of PCC. Paving machines shall use a mechanical spreading device capable of distributing the material transversely, uniformly, and without segregation. Do not use non-self-propelled screeds unless approved by the Engineer. Protect previously placed pavement from paving machine tracks using cushions comprised of rubber or wood. Operate paving machines at a steady pace that conforms to the manufacturer's recommendations and provides a satisfactory finish.

Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times. Use an internal tube vibrator whenever a vibrating screed is used.

Joint cutting saws shall use a water-cooled, diamond-tipped blade. Saws shall have an adjustable guide pointer. Keep a minimum of two (2) operational saws on-site at all times. When approved, early-entry saws shall conform to the requirements of the Engineer. At a minimum, equip early-entry saws with an anti-ravel skid plate. Replace the anti-ravel skid plate as directed by the manufacturer.

Hot-applied joint sealant applicators shall consist of a double-walled melting pot with a mechanical agitator that continuously stirs the material. The heating unit shall not apply direct heat to the sealant material. Applicators shall use a pressurized system for placing the material. Applicators shall have flow controls that allow the operator to control the flow of the heated material. Use an applicator nozzle that fills the joint from the bottom to the top. Cold-applied joint sealant applicators shall conform to the requirements established by the sealant manufacturer.

Keep a sufficient number of ten (10) foot straightedges and a six (6) inch steel channel master straightedge with a minimum length of ten (10) feet on-site at all times.

(B) Forms for PCC.

Forms shall be rigid, straight metal. The maximum deflection of forms shall not exceed one-eighth ($^1/_8$) inch in ten (10) feet when tested as a simple beam and subjected to a center load of one thousand seven hundred (1,700) pounds. Clean and oil forms before PCC placement.

The minimum length shall be ten (10) feet. The depth shall be equivalent to the design thickness at the edge of the PCC. Bolt additional forms to the top of a form as necessary to achieve additional depth. Use a minimum of three (3) anchors for each individual form.

Radius forms may be comprised of wood or metal. Wood radius forms shall be rigid and finished on the PCC side of the form. The rigidity of the radius forms shall be as needed to resist deformation under the PCC load. Anchor radius forms as necessary to maintain the shape of the radius.

Bed and join forms neatly and tightly to line and grade in a manner that resists movement. Do not place forms on pedestals to maintain proper grade. Remove and reset forms that vary more than one-eighth ($^1/_8$) inch in ten (10) feet from line or grade.

Use the edge of existing PCC as a form as necessary provided the existing PCC has a smooth vertical face or a keyed face that is free of soil or other contaminants.

(C) Pre-formed Expansion Joints.

Construct pre-formed expansion joints at the locations indicated in the Contract Documents. Place the pre-molded joint filler across the transverse length of the pavement and extend from one (1) inch below the PCC surface to the bottom of the PCC. Maintain the position of the pre-molded joint filler in a manner acceptable to the Engineer. Shape the pre-molded joint filler to match the shape of the integral curb attached to the pavement.

After placing the PCC, place joint sealant atop the pre-molded joint filler to one-fourth (¼) inch below the pavement surface.

(D) Placing Reinforcing Steel.

Place steel reinforcement as directed by the Contract Documents. Overlap adjacent sheets of wire fabric or bar mats a minimum of twelve (12) inches. Keep sheets and mats straight during and after installation. Tie lapped sheets using steel wire or other material acceptable to the Engineer. Tie longitudinal laps at a spacing of twenty-four (24) inches or less. Tie transverse laps at a spacing of sixty (60) inches or less.

Place the reinforcement a maximum of three (3) inches from a longitudinal construction or expansion joint and a maximum of two (2) inches from a transverse construction or expansion joint. Place the reinforcement within one-fourth (¼) inch of the elevation required in the Contract Documents. Position the reinforcement before placing the PCC. Use metal supports acceptable to the Engineer to maintain the position of the reinforcement. Do not place any load on positioned reinforcement that causes the reinforcement to move out of position. Maintain the position of the reinforcement before, during, and after PCC placement.

Place reinforcement mechanically using equipment designed and intended for this purpose and approved by the Engineer. Mechanically placed reinforcement is subject to the positioning requirements for manually placed reinforcement.

Uniformly lubricate one-half (½) of the length of any dowel bars using a petroleum-based oil or grease. Coat the bar with a maximum coating thickness of one-thirty second ($^{1}/_{32}$) inch. The lubricant coloring shall contrast with the coloring of the non-lubricated dowel bar.

(E) Placing PCC.

Before commencing PCC placement, adjust all appurtenances to the required grade and alignment or form the area around the appurtenance to allow for adjusting later. Construct a PCC header sized and located as indicated in the Contract Documents. For colored PCC applications and imprinted applications, prepare a complete test sample of the PCC for approval by the Engineer before commencing construction of the colored or imprinted PCC.

Provide sufficient lighting for placement and finishing operations as instructed by the Engineer. Do not place PCC at night or in low-light conditions without the Engineer's permission.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate

the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of construction joints to achieve a saturated surface-dry condition immediately before PCC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

For evaporation rates greater than fifteen-hundredths pounds per square feet per hour (0.15 lbs/ft²/hr), take precautions against shrinkage cracking using methods acceptable to the Engineer. For evaporation rates greater that two-tenths pounds per square feet per hour (0.2 lbs/ft²/hr), cease PCC placement. Determine the evaporation rate in accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[1]

[1] Figure reprinted with written permission from ACI International.

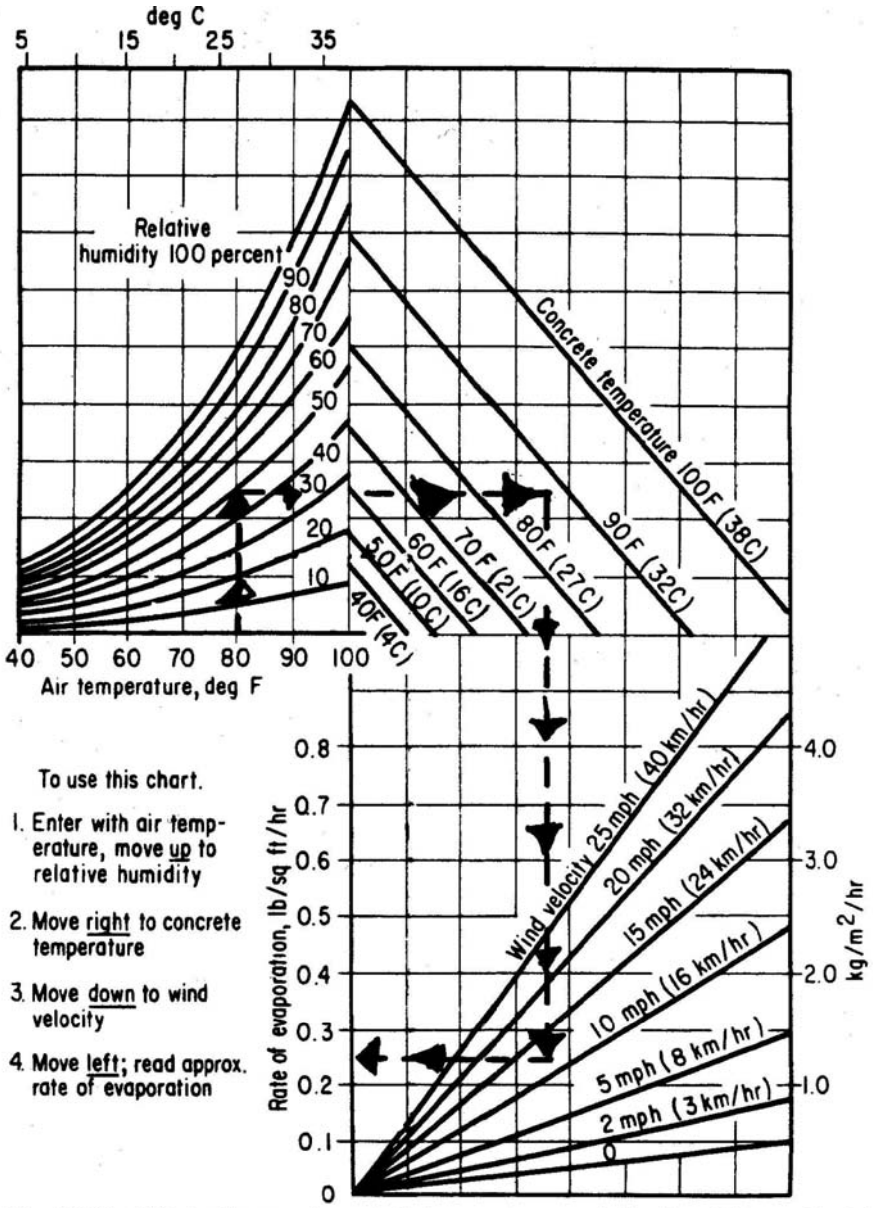

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

During cold weather periods, do not commence PCC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature

falls below forty (40) degrees Fahrenheit. Do not place PCC below the minimum allowable temperature without prior authorization by the Engineer. Maintain the temperature of the PCC at or above fifty (50) degrees Fahrenheit for a minimum of 3 days. Provide external heat sources and insulating blankets or other insulating materials as necessary. Do not place PCC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the PCC in a manner that minimizes segregation.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

After placing and before striking off, consolidate PCC using internal vibration provided by one (1) or more tube vibrators. Insert and immediately remove manual vibrators at regular intervals less than

three (3) feet apart. Do not drag manual vibrators through the PCC. Use machine-mounted vibrators in accordance with the manufacturer's recommendations. Use a tube vibrator when using a vibrating screed.

Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC.

At the completion of the placement or if the placement is interrupted by more than thirty (30) minutes place, a transverse construction joint extending the full width and depth of the placement. Locate transverse construction joints in the placed PCC at the location of the closest joint indicated in the Contract Documents.

(F) Finishing, Curing, and Protecting PCC Pavement.

Strike off and finish the PCC to the elevation specified in the Contract Documents using equipment and techniques acceptable to the Engineer. Use a slip-form paver, rail-guided finishing machine, vibrating metal screed, or other mechanical equipment acceptable to the Engineer to strike off and finish the PCC unless otherwise approved by the Engineer. Hand finish as necessary.

Remove material build-up from the forms before strike off or finishing begins. Vibrating screeds shall have a minimum weight of eight (8) pounds per linear foot and a minimum vibration frequency of three thousand five hundred (3,500) revolutions per minute at any point along the screed.

Operate the finishing equipment at a uniform speed in accordance with the manufacturer's recommendations. Adjust the speed of the finishing equipment if surface distressing occurs.

Immediately after mechanical finishing, true the surface using a ten (10) foot straightedge placed parallel and perpendicular to the direction of placement. Round the edges of the PCC surface using a one (1) inch diameter edging tool. Correct any irregularities in the surface and hand finish as needed.

Minimize screeding, floating, and troweling operations to avoid overworking or over-manipulation of the PCC. Remove any free water present on the PCC surface between finishing operations in a manner acceptable to the Engineer. Do not use neat cement or sand-cement mixtures to remove free water. Do not use finishing tools on PCC having free water present on the surface.

Apply an evaporation retardant acceptable to the Engineer to aid in the finishing of the surface as necessary. Water added to the surface will not be allowed. Add an evaporation retardant or water by misting.

Immediately remove excessive amounts of water as determined by the Engineer in a manner acceptable to the Engineer. Do not conduct finishing operations if free water is present on the PCC surface.

Upon completion of the finishing operation, texture the PCC surface by a wet, double-burlap drag or broom-finish. Drag the burlap parallel to the placement direction. Broom-finish the surface uniformly and perpendicular to the placement direction. Mist water on the burlap to maintain adequate moisture in the burlap. Do not pressure spray or otherwise apply excessive amounts of water onto any burlap that is atop fresh PCC. Clean the burlap and brooms as needed to prevent build-up. Replace the burlap or broom if the build-up mars the PCC surface.

For driveway paving, Imprint the name of the Contractor and the year of construction into the unhardened PCC surface using a pre-fabricated stamp acceptable to the Engineer. Use block letters between one (1) and two (2) inches in height. The depth of the imprint shall be three-eighths (3⁄8) to one-half (½) inches. Imprint every one hundred (100) linear feet or as directed by the Engineer.

For imprint applications, apply the imprint form after the finishing operation and while the PCC surface is in a plastic stage. Apply the imprint forms perpendicular to the PCC edge or centerline.

Within one (1) hour of PCC placement, protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer. Do not use liquid membrane-forming curing compounds for PCC base that will receive an ACP surface. Do not use asphalt emulsion for a curing material on PCC pavement, PCC overlay, or PCC surface repair. For colored PCC applications, thin the liquid curing compound in accordance with the manufacturer's instructions and apply at the application rate recommended by the manufacturer.

Apply PCC stains in accordance with the manufacturer's recommendations.

(G) Contraction Joints.

Saw longitudinal and transverse contraction joints at the dimensions and intervals indicated in the Contract Documents. Sawing shall begin as soon as the PCC has sufficiently hardened to allow sawing without tearing or raveling. Once the sawing operation begins, the Contractor shall continue sawing until completed. Use a straight, chalked line or other reference acceptable to the Engineer for guiding the line of the saw. Continue all saw-cuts through any new gutter, combination curb

and gutter, or integral curb attached to the PCC. Sequence the sawing to prevent random cracking. Do not use early-entry saws without prior approval by the Engineer. Early entry saws shall cut a minimum of one-sixth ($^1/_6$) of the depth of the PCC, but not less than one (1) inch for any PCC thickness.

At the Engineer's sole discretion and direction, the contractor may route and seal cracks in lieu of replacing cracked panels. The Contractor shall route random cracks to a minimum depth of one (1) inch and a maximum width of three-eighths ($^3/_8$) inch. Concrete-colored urethane based caulk shall be used where directed by the Engineer. The Contractor is responsible for cost of this repair work.

Seal or apply curing compound to all contraction joints and routed cracks within twenty-four (24) hours of sawing or routing. Clean the contraction joints and routed cracks immediately before sealing operations. Place joint sealant in the sawed contraction joints and routed cracks to one-fourth (¼) inch below the PCC surface.

(H) Construction Joints.

Construct longitudinal and transverse construction joints to the dimensions indicated in the Contract Documents. Clean the construction joint immediately before sealing operations. Place joint sealant in the construction joint to one-fourth (¼) inch below the pavement surface.

(I) Defective or Substandard PCC.

Remove and replace in accordance with the Contract Documents any portion(s) of the PCC placement that contains random cracking, plastic shrinkage cracking, scaling, high spots, depressions, or other defects or substandard conditions as determined by the Engineer. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

The maximum allowable deviation from plane is one-fourth (¼) inch in any ten (10) foot span. The maximum allowable deviation from the specified elevation is minus zero (-0), plus one-half (+½) inch provided the deviation does not alter the designed drainage pattern. The maximum allowable deviation for horizontal alignment is one (1) inch. The maximum allowable deviation for horizontal alignment at tie-in locations is one-half (½) inch.

Correct surface deviations by removing and replacing the non-complying section of pavement or by grinding the pavement using a diamond-tipped grinding wheel or other equipment satisfactory to the Engineer. Perform grinding in a manner that does not alter the designed drainage pattern or damage the structural soundness of the remaining PCC. Do not grind the PCC if the PCC will not meet elevation or thickness requirements after grinding. Correct any damage to the joint sealant in a manner acceptable to the Engineer.

Remove defective or substandard PCC to the nearest joint in all directions unless otherwise directed by the Engineer. At the discretion of the Engineer, route and seal random cracks or plastic shrinkage cracks in lieu of PCC removal and replacement.

(J) Opening Pavement for Use.
Seal all joints before opening a section of pavement to traffic. Do not open the pavement to traffic until the PCC has reached a compressive strength of three thousand (3,000) psi. Determine the compressive strength in accordance with ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens. At the discretion of the Engineer, the compressive strength used for opening the pavement may be determined using ASTM C1074, Standard Practice for Estimating Concrete Strength by the Maturity Method as modified by the City of Omaha Materials Testing Manual for Public Works Construction.

(K) Requirements for Thickness.
Verify the thickness of the pavement by coring in accordance with ASTM C174, Standard Test Method for Measuring the Thickness of Concrete Elements Using Drilled Concrete Cores. Deliver the cores to the Engineer for measurement.

501.04 Measurement and Payment.

The Engineer may assess pay deductions for failure to meet the requirements outlined above in accordance with Table 501.02. If the project consists of multiple streets or locations along the same street(s), the Engineer shall determine a separate, pay factor for each individual location or continuous segment of a street. The Engineer shall determine pay factors using the average of a minimum of three (3) samples. The sample locations shall be determined by the guidelines set forth in the City of Omaha Materials and Testing Manual. The Engineer reserves the right to combine locations having less than three (3) samples with the next location constructed.

The total pay factor equals the product of the individual pay factors for the measured properties. If any pay factor for the measured property indicates rejected material, remove and replace such material at no additional cost to the City. The Engineer reserves the right to accept rejected material at a total pay factor of fifty (50) percent. Unless otherwise indicated in the Contract Documents, the maximum total pay factor shall equal one (1.00).

The Contractor may request one (1) re-test of the compressive strength and/or thickness. The Engineer shall retest the PCC using cores obtained in accordance with ASTM C174, Standard Test Method for Measuring the Thickness of Concrete Elements Using Drilled Concrete Cores. The Engineer shall combine the results of the re-tests with those of the original tests and compute a new total average.

The Engineer shall omit individual pay factors if such items are not required. The Engineer shall compute the individual pay factor as follows:

Table 501.02
PCC Pay Factor Determination

Measured Property	Average Measured Value		Pay Factor
Deviation from Minimum 28-day Compressive Strength, psi	≥ 1,000 above minimum		1.05
	0 to -250		1.00
	-250 to -500		0.95
	-501 to –750		0.90
	-751 to –1000		0.80
	< -1,001		Reject
Air Content[1], %	6.25-6.75		1.05
	5.50-6.24	6.76-7.50	1.00
	4.75-5.49	7.51-8.25	0.95
	4.00-4.74	8.26-9.00	0.85
	3.25-3.99	9.01-9.75	0.75
	< 3.25	> 9.75	Reject
Deviation from Design Thickness[2,3], inches	0.0 to 0.25		1.00
	0.26 to 0.50		0.90
	0.51 to 0.75		0.75
	0.76 to 1.00		0.50
	> 1.00		Reject

1 – Based upon field testing of fresh concrete
2 – Absolute Value of the difference from the thickness required by the Contract Documents when measured using cores.
3 – For resurfacing/overlay projects, omit this individual Pay Factor unless otherwise indicated in the Contract Documents.

The Engineer shall measure PCC pavement for payment by the pay factor multiplied by the total number of square yards of PCC pavement constructed and accepted.

The Engineer shall measure PCC overlay for payment by the pay factor multiplied by the total number of cubic yards of PCC overlay constructed and accepted.

The Engineer shall measure PCC header for payment by the total number of linear feet of PCC header constructed and accepted.

The Engineer shall measure PCC pavement beam for payment by the total number of linear feet of PCC pavement beam constructed and accepted.

The Engineer shall measure PCC pavement repair for payment by the pay factor multiplied by the total number of square yards of PCC pavement repair constructed and accepted.

The Engineer shall measure PCC driveway repair for payment by the total number of square yards of PCC driveway repair constructed and accepted.

Perform corrective action or removal and replacement activities at no additional cost to the City.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for obtaining pavement cores and for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
___-inch Concrete Pavement (Type ____)	Square Yard
Concrete Overlay (Type ____)	Cubic Yard
___-inch Concrete Base (Type ____)	Square Yard
___-inch Concrete Driveway (Type ____)	Square Yard
Concrete Pavement Beam	Linear Foot
Concrete Header	Linear Foot
Concrete Pavement Repair (Less than ___ Square Yards)	Square Yard
Concrete Pavement Repair (Greater than or equal to ___ Square Yards)	Square Yard
Concrete Pavement Repair (Type ____)	Square Yard
Repair Concrete Driveway	Square Yard

502 – PCC CURB, COMBINATION CURB AND GUTTER, AND INTEGRAL CURB

502.01 Description.

The work includes construction of PCC curb, combination curb and gutter, or integral curb constructed on prepared subgrade, base, or subbase in accordance with the specifications, lines, grades, and cross sections indicated in the Contract Document or established by the Engineer. The work includes removal or preparation of the existing pavement or materials and construction of PCC curb, combination curb and gutter, or median nose at locations indicated by the Contract Documents or designated by the Engineer.

502.02 Material Requirements.

(A) Portland Cement for PCC.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 2 (Maximum Equivalent Alkalies requirements only) and Table 3. Do not use blended hydraulic cements without prior approval of the Engineer. Blended hydraulic cements shall conform to the requirements of ASTM C595, Standard Specification for Blended Hydraulic Cements.

(B) Aggregate for PCC.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(C) Water for PCC.
All water used in the PCC mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(D) Admixtures for PCC.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete, ASTM C1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete, or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of

calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC. Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(E) Coloring Agent for PCC.

Coloring agent shall comply with the requirements of ASTM C979, Pigments for Integrally Colored Concrete. Add coloring agent in accordance with the manufacturer's recommendations. The maximum allowable dosage for a coloring agent is ten (10) percent of the total weight of cementitious materials.

(F) PCC Stain for PCC.

PCC stain shall be a waterborne, acrylic-based stain designed for the intended use and acceptable to the Engineer.

(G) Pre-molded Joint Filler.

Pre-molded joint filler for expansion joints shall conform to the requirements of ASTM D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). Neatly punch holes to admit the dowels where indicated in the Contract Documents. The diameter of the holes shall not exceed one-half (½) inch greater than the bar diameter. When more than one piece is required for a joint, securely fasten the abutting ends by stapling or other positive fastening means satisfactory to the Engineer.

(H) Pressure Relief Joint Filler.

Pressure relief joint filler shall conform to the requirements of ASTM D3204, Standard Specification for Preformed Cellular Plastic Joint Fillers for Relieving Pressure.

(I) Joint Sealant.

Joint sealant shall be a polyurethane, silicone, or bitumastic liquid material intended for use as a PCC pavement sealant and shall conform to the requirements of C920, Standard Specification for Elastomeric Joint Sealants; ASTM D5893, Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements; or ASTM D6690, Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements. For colored PCC applications, color-match the

sealing compound to the colored PCC. The Engineer shall approve the color match before application begins.

(J) Reinforcement for PCC.

Welded wire fabric shall conform to the requirements of ASTM A185, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement. Welded bar mats shall conform to the requirements of ASTM A704, Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement. Tie bars shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60, rail steel bars for tie bars bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement. Keep reinforcing metal clean and free of rust or foreign material. Protect reinforcing materials from weather until placement. Supply and store welded wire sheets and welded bar mats in flat sheets.

(K) Curing Materials for PCC.

Curing materials shall be liquid, membrane forming compounds or polyethylene sheeting. Liquid, membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene sheeting for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

(L) PCC Mix Proportioning and Required Properties.

Proportion PCC mixtures to meet the requirements of Table 502.01. Do not use fly ash in the PCC mixture. Manufacture the PCC in accordance with ASTM C94, Standard Specification for Ready-Mixed Concrete.

Table 502.01
PCC Properties

Mix Type	L6	L65
Portland Cement Content, lbs. per cu. yd.	564 min.	611 min.
Coarse Aggregate, % of Total Aggregate	30±3	30±3
Fine Aggregate, % of Total Aggregate	70±3	70±3
Maximum Water Cement Ratio	0.45	0.45
Minimum 28-Day Compressive Strength, psi	3500	4000
Air Content, %	6.5±1.0	6.5±1.0
Slump (Formed Pavement), inches	2.5±1.5	2.5±1.5
Slump (Slip-form Pavement), inches	1.5±1.5	1.5±1.5
PCC Temperature during placement, °F	70±20	70±20

Referenced Test Procedures:

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

502.03 Construction Requirements.

(A) Equipment.

The National Ready Mixed Concrete Association shall certify that the PCC production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the PCC production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

The production facility shall provide the batch information for each load of PCC delivered to the site. The batch information shall accompany each load delivered to the site. At a minimum, the batch information shall include the component materials, the actual batch weights and target batch weights of component materials, free moisture content of aggregates, water cement ratio of batch, and amount of additional water added at production facility after batching.

Curb and gutter machines shall be self-propelled and capable of spreading and striking off the necessary quantity of PCC. Curb and gutter machines shall use a mechanical spreading device that distributes the material uniformly and without segregation. When directed by the Engineer, protect all adjacent structures or pavement from curb and gutter machine tracks using cushions comprised of rubber or wood. Operate the curb and gutter machine at a steady pace that conforms to the manufacturer's recommendations and provides a satisfactory finish.

Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on-site at all times.

Joint cutting saws shall use a water-cooled, diamond-tipped blade. Keep a minimum of two (2) operational saws on-site at all times.

Hot-applied joint sealant applicators shall consist of a double-walled melting pot with a mechanical agitator that continuously stirs the material. The heating unit shall not apply direct heat to the sealant material. Applicators shall use a pressurized system for placing the material. Applicators shall have flow controls that allow the operator to control the flow of the heated material. Use an applicator nozzle that fills the joint from the bottom to the top. Cold-applied joint sealant applicators shall conform to the requirements established by the sealant manufacturer.

Keep a sufficient number of ten (10) foot straightedges and a six (6) inch steel channel master straightedge with a minimum length of ten (10) feet on-site at all times.

(B) Forms for PCC.

Forms shall be rigid, straight metal. The maximum deflection of forms shall not exceed one-eighth ($^1/_8$) inch in ten (10) feet when tested as a simple beam and subjected to a center load of one thousand seven hundred (1,700) pounds. Clean and oil forms before PCC placement.

The minimum length shall be ten (10) feet. The depth shall be equivalent to the design thickness at the edge of the PCC. Bolt additional forms to the top of a form to achieve additional depth. Use a minimum of three (3) anchors for each individual form.

Radius forms may be comprised of wood or metal. Wood radius forms shall be rigid and finished on the PCC side of the form. The rigidity of the radius forms shall be as needed to resist deformation under the PCC load. Anchor radius forms as necessary to maintain the shape of the radius.

Bed and join forms neatly and tightly to line and grade in a manner that resists movement. Do not place forms on pedestals to maintain proper grade. Remove and reset forms that vary more than one-eighth ($^1/_8$) inch in ten (10) feet from line or grade.

Using the edge of existing PCC as a form is acceptable provided the existing PCC has a smooth vertical face or a keyed face that is free of soil or other contaminants.

(C) Pre-formed Expansion Joints.

Construct pre-formed expansion joints at the locations indicated in the Contract Documents. Place the pre-molded joint filler across the transverse length of the pavement and extend from one (1) inch below the PCC surface to the bottom of the PCC. Maintain the position of the pre-molded joint filler in a manner acceptable to the Engineer. Shape the pre-molded joint filler to match the shape of the curb attached to the pavement.

After placing the PCC, place joint sealant atop the pre-molded joint filler to one-fourth (¼) inch below the pavement surface.

(D) Pressure Relief Joints.

Construct pressure relief joints at the locations indicated in the Contract Documents. The longitudinal width of the pressure relief joint shall be four (4) inches with an allowable deviation of one-fourth (¼) inch at the time of construction. The pressure relief joint shall extend throughout the full width and depth of the surrounding pavement.

The surrounding surfaces shall be dry and free of dirt, grease, or other contaminants. Install the pressure relief joint filler in accordance with the manufacturer's instructions.

(E) Placing Reinforcing Steel.

Place steel reinforcement as directed by the Contract Documents. Place the reinforcement within one-fourth (¼) inch of the elevation required in the Contract Documents. Position the reinforcement before placing the PCC. Use metal supports acceptable to the Engineer to maintain the position of the reinforcement. Do not place any load on positioned reinforcement that causes the reinforcement to move out of position. Maintain the position of the reinforcement before, during, and after PCC placement.

Uniformly lubricate one-half (½) of the length of any dowel bars using a petroleum-based oil or grease. The lubricant shall coat the bar with a maximum coating thickness of one-thirty second ($^1/_{32}$) inch. The lubricant coloring shall contrast with the coloring of the non-lubricated dowel bar.

(F) Placing PCC.

Provide sufficient lighting for placement and finishing operations as instructed by the Engineer. Do not place PCC at night or in low-light conditions without the Engineer's permission. For colored PCC applications and imprinted applications, prepare a complete test sample of the PCC for approval by the Engineer before commencing construction of the colored or imprinted PCC.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of construction joints to achieve a saturated surface-dry condition immediately before PCC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

For evaporation rates greater than two-tenths pounds per square feet per hour (0.2 lbs/ft^2/hr), take precautions against shrinkage cracking acceptable to the Engineer. Determine the evaporation rate in accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[2]

[2] Figure reprinted with written permission from ACI International.

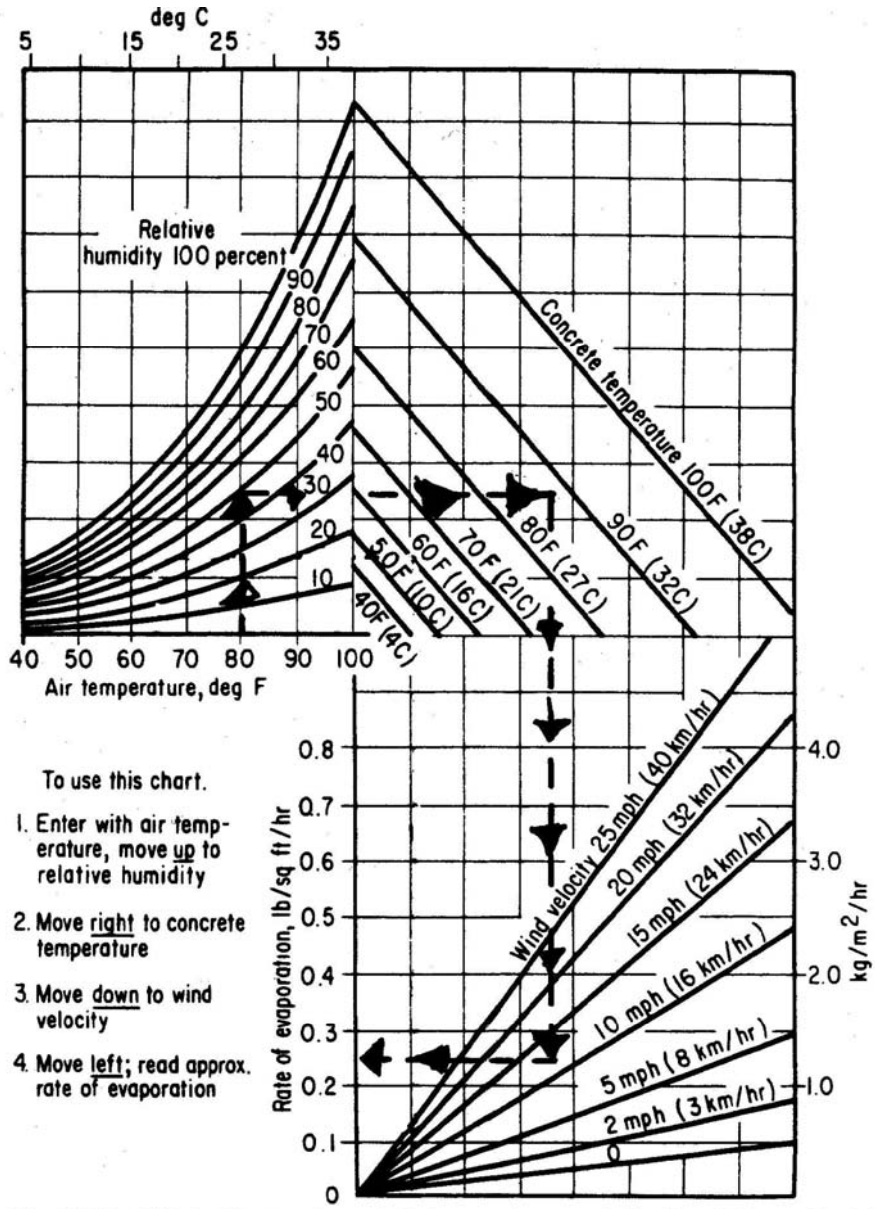

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

During cold weather periods, do not commence PCC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature

falls below forty (40) degrees Fahrenheit. Do not place PCC below the minimum allowable temperature without prior authorization by the Engineer. PCC placement below the minimum temperatures shall include all necessary measures to maintain the temperature of the PCC at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days. Do not place PCC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

Construct a header sized and located as indicated in the Contract Documents. Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the PCC in a manner that minimizes segregation.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

After placing and before striking off, consolidate PCC using internal vibration provided by a tube vibrator. Insert and immediately remove manual vibrators at regular intervals less than three (3) feet apart without dragging. Use machine-mounted vibrators in accordance with the manufacturer's recommendations.

Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC.

At the completion of the placement or if the placement is interrupted by more than thirty (30) minutes, place a transverse construction joint extending the full width and depth of the placement. Locate the transverse construction joint in the placed PCC at the location of the closest joint indicated in the Contract Documents.

(G) Finishing, Curing, and Protecting PCC Pavement.

Strike off and finish the PCC to the elevation specified in the Contract Documents using equipment and techniques acceptable to the Engineer. Before commencing strike-off or finishing, remove any material or material build-up from the top of the forms. Immediately after mechanical finishing, true the surface using a ten (10) foot straightedge placed parallel and perpendicular to the direction of placement. Round the edges of the PCC surface using a one (1) inch diameter edging tool. Correct any irregularities in the surface and hand finish as needed.

Adding a minimal amount of water to the PCC surface to aid in finishing is acceptable. Add water only by misting. Immediately remove excessive amounts of water as determined by the Engineer in a manner acceptable to the Engineer. Do not conduct finishing operations if free water is present on the PCC surface.

Upon completion of the finishing operation, texture the PCC surface by a wet, double-burlap drag or broom-finish. Drag the burlap parallel to the gutter direction. Mist water on the burlap to maintain adequate moisture in the burlap. Do not pressure spray or otherwise apply excessive amounts of water onto any burlap that is atop fresh PCC. Clean the burlap and brooms as needed to prevent build-up. Replace the burlap or broom if the build-up mars the PCC surface.

Imprint the name of the Contractor and the year of construction into the unhardened PCC surface using a pre-fabricated stamp acceptable to the Engineer. Use block letters between one (1) and two (2) inches in height. The depth of the imprint shall be three-eighths ($^3/_8$) to one-half (½) inches. Imprint every one hundred (100) linear feet or as directed by the Engineer.

Within one (1) hour of PCC placement, protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer. Do not use liquid membrane-forming curing compounds for PCC base that will receive an ACP surface. Do not use asphalt emulsion for a curing material on PCC pavement, PCC overlay, or PCC surface repair. For colored PCC applications, thin the liquid curing compound in accordance with the manufacturer's instructions and apply at the application rate recommended by the manufacturer.

Apply PCC stains in accordance with the manufacturer's recommendations.

(H) Contraction Joints.

Saw transverse contraction joints at the dimensions and intervals indicated in the Contract Documents. Sawing shall begin as soon as the PCC has sufficiently hardened to allow sawing without tearing or raveling. Sequence the sawing to prevent random cracking. Route random cracks to a minimum depth of one (1) inch and a maximum width of three-eighths (3/8) inch. Seal or apply curing compound to the contraction joint or routed crack within twenty-four (24) hours of sawing or routing. Clean the contraction joints and routed cracks immediately before sealing operations. Place joint sealant in the sawed contraction joints and routed cracks to one-fourth (¼) inch below the PCC surface.

(I) Construction Joints.

Construct longitudinal and transverse construction joints to the dimensions indicated in the Contract Documents. Clean the construction joint immediately before sealing operations. Place joint sealant in the construction joint to one-fourth (¼) inch below the PCC surface.

(J) Defective or Substandard PCC.

Remove and replace in accordance with the Contract Documents any portion(s) of the PCC placement that contains random cracking, plastic shrinkage cracking, scaling, high spots, depressions, or other defects or substandard conditions as determined by the Engineer. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

The maximum allowable deviation from plane is one-fourth (¼) inch in any ten (10) foot span. The maximum allowable deviation from the specified elevation is minus zero (-0), plus one-half (+½) inch provided the deviation does not alter the designed drainage pattern. The

maximum allowable deviation for horizontal alignment is one (1) inch. The maximum allowable deviation for horizontal alignment at tie-in locations is one-half (½) inch.

Correct surface deviations by removing and replacing the non-complying section of the PCC or by grinding the PCC using a diamond-tipped grinding wheel or other equipment satisfactory to the Engineer. Perform grinding in a manner that does not alter the designed drainage pattern or damage the structural soundness of the remaining PCC. Do not grind the PCC if the PCC will not meet elevation or thickness requirements after grinding. Correct any damage to the joint sealant in a manner acceptable to the Engineer.

Remove defective or substandard PCC to the nearest joint in all directions unless otherwise directed by the Engineer. At the discretion of the Engineer, route and seal random cracks or plastic shrinkage cracks in lieu of PCC removal and replacement.

(K) Opening PCC for Use.
Seal all joints before opening a section of PCC to traffic. Do not open the PCC to traffic until the PCC has reached a compressive strength of three thousand (3,000) psi. Determine the compressive strength in accordance with ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens. At the discretion of the Engineer, the compressive strength used for opening the pavement may be determined using ASTM C1074, Standard Practice for Estimating Concrete Strength by the Maturity Method as modified by the City of Omaha Materials Testing Manual for Public Works Construction.

(L) Requirements for Thickness.
Verify the thickness of the PCC by coring in accordance with ASTM C174, Standard Test Method for Measuring the Thickness of Concrete Elements Using Drilled Concrete Cores. Deliver the cores to the Engineer for measurement.

502.04 Measurement and Payment.

The Engineer shall measure integral curb for payment by the total number of linear feet of integral curb face constructed and accepted.

The Engineer shall measure vertical curb for payment by the total number of linear feet of vertical curb face constructed and accepted.

The Engineer shall measure combination curb and gutter for payment by the total number of linear feet of combination curb and gutter face constructed and accepted.

The Engineer shall measure ramp curb for payment by the total number of linear feet of ramp curb face constructed and accepted.

The Engineer shall measure PCC curb repair for payment by the total number of linear feet of PCC curb face repaired and accepted.

The Engineer shall measure combination curb and gutter repair for payment by the total number of linear feet of curb and gutter face repaired and accepted.

The Engineer shall measure saw cutting for PCC curb repair for payment by the total number of linear feet of PCC curb face sawed and accepted.

Perform any corrective action or removal and replacement activities at no additional cost to the City.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Construct Integral Curb (Type ___)	Linear Foot
Construct Vertical Curb	Linear Foot
Construct Combination Curb And Gutter	Linear Foot
Construct Ramp Curb	Linear Foot
Repair Concrete Curb	Linear Foot
Repair Combination Curb And Gutter	Linear Foot
Saw Cut for Concrete Curb Repair	Linear Foot

THIS PAGE INTENTIONALLY LEFT BLANK

503 – PCC SIDEWALK, MOW STRIP, AND MEDIAN SURFACING

503.01 Description.

The work includes construction of PCC sidewalk, PCC sidewalk repair, mow strip, or median surfacing constructed on prepared subgrade, base, or subbase in accordance with the specifications, lines, grades, and cross sections indicated in the Contract Documents or established by the Engineer. The work includes curb grinding for construction of a wheelchair ramp and removal of the existing pavement, curb, or materials and construction or replacement of PCC sidewalk, PCC sidewalk repair, mow strip, or median surfacing at locations indicated in the Contract Documents or designated by the Engineer. In general, construct PCC sidewalk repair on prepared subgrade, base, or subbase where vertical displacement or failure in the existing sidewalk has developed in accordance with the Contract Documents. The minimum thickness of the PCC sidewalk repair shall be four (4) inches or the thickness of the existing sidewalk whichever is greater. The repair areas shall be rectangular with edges parallel and perpendicular to the existing joint pattern.

503.02 Material Requirements.

(A) Portland Cement for PCC.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 2 (Maximum Equivalent Alkalies requirements only) and Table 3. Do not use blended hydraulic cements without prior approval of the Engineer. Blended hydraulic cements shall conform to the requirements of ASTM C595, Standard Specification for Blended Hydraulic Cements.

(B) Aggregate for PCC.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(C) Water for PCC.
All water used in the PCC mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(D) Admixtures for PCC.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete, ASTM C1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete, or ASTM C260, Standard Specification

of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC. Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(E) Coloring Agent for PCC.

Coloring agent shall comply with the requirements of ASTM C979, Pigments for Integrally Colored Concrete. Add coloring agent in accordance with the manufacturer's recommendations. The maximum allowable dosage for a coloring agent is ten (10) percent of the total weight of cementitious materials.

(F) PCC Stain for PCC.

PCC stain shall be a waterborne, acrylic-based stain designed for the intended use and acceptable to the Engineer.

(G) Pre-molded Joint Filler.

Pre-molded joint filler for expansion joints shall conform to the requirements of ASTM D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). When more than one piece is required for a joint, securely fasten the abutting ends by stapling or other positive fastening means satisfactory to the Engineer.

(H) Joint Sealant.

Joint sealant shall be a polyurethane, silicone, or bitumastic liquid material intended for use as a PCC pavement sealant and shall conform to the requirements of C920, Standard Specification for Elastomeric Joint Sealants; ASTM D5893, Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements; or ASTM D6690, Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements. For colored PCC applications, color-match the sealing compound to the colored PCC. The Engineer shall approve the color match before application begins.

(I) Reinforcement for PCC.

Welded wire fabric shall conform to the requirements of ASTM A185, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement. Welded bar mats shall conform to the requirements of ASTM A704, Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement. Tie bars shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60, rail steel bars for tie bars bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement. Keep reinforcing metal clean and free of rust or foreign material. Protect reinforcing materials from weather until placement. Supply and store welded wire sheets and welded bar mats in flat sheets.

(J) Curing Materials for PCC.

Curing materials shall be liquid, membrane forming compounds or polyethylene sheeting. Liquid, membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene sheeting for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

(K) PCC Mix Proportioning and Required Properties.

Proportion PCC mixtures to meet the requirements of Table 503.01. Do not use fly ash in the PCC mixture. Manufacture the PCC in accordance with ASTM C94, Standard Specification for Ready-Mixed Concrete.

Table 503.01
PCC Properties

Mix Type	SG65	L6
Portland Cement Content, lbs. per cubic yard	611 min.	564 min.
Coarse Aggregate, % of Total Aggregate	0	30±3
Fine Aggregate, % of Total Aggregate	100	70±3
Maximum Water Cement Ratio	0.45	0.45
Minimum 28-Day Compressive Strength, psi	3500	3500
Air Content, %	6.5±1.0	6.5±1.0
Slump (Formed Pavement), inches	2.5±1.5	2.5±1.5
Slump (Slip-form Pavement), inches	1.5±1.5	1.5±1.5
PCC Temperature during placement, °F	70±20	70±20

Referenced Test Procedures:

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens

- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

503.03 Construction Requirements.

(A) Equipment.

Provide all equipment, labor, and tools necessary to perform the work to the satisfaction of the Engineer. The National Ready Mixed Concrete Association shall certify that the PCC production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

The production facility shall provide the batch information for each load of PCC delivered to the site. The batch information shall accompany each load delivered to the site. At a minimum, the batch information shall include the component materials, the actual batch weights and target batch weights of component materials, free moisture content of aggregates, water cement ratio of batch, and amount of additional water added at production facility after batching.

Paving machines shall be capable of spreading and striking off the necessary quantity of PCC. Spread the PCC uniformly and without segregation. Use hand operated or non-self propelled screeds only with the approval of the Engineer. Protect adjacent materials and structures from paving machine tracks using cushions comprised of rubber or wood. Operate the paving machine at a steady pace that conforms to the manufacturer's recommendations and provides a satisfactory finish.

Vibrators shall be internal, tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times. Use an internal tube vibrator whenever a vibrating screed is used.

Joint cutting saws shall use a water-cooled, diamond-tipped blade. Saws shall have an adjustable guide pointer. Keep a minimum of two (2) operational saws on-site at all times. When approved, early-entry

saws shall conform to the requirements of the Engineer. At a minimum, equip early-entry saws with an anti-ravel skid plate. Replace the anti-ravel skid plate as directed by the manufacturer.

Hot-applied joint sealant applicators shall consist of a double-walled melting pot with a mechanical agitator that continuously stirs the material. The heating unit shall not apply direct heat to the sealant material. Applicators shall use a pressurized system for placing the material. Applicators shall have flow controls that allow the operator to control the flow of the heated material. Use an applicator nozzle that fills the joint from the bottom to the top. Cold-applied joint sealant applicators shall conform to the requirements established by the sealant manufacturer.

Keep a sufficient number of ten (10) foot straightedges and a six (6) inch steel channel master straightedge with a minimum length of ten (10) feet on site at all times.

Imprinting forms shall be rigid metal forms acceptable to the Engineer and textured with the design indicated in the Contract Documents.

Curb grinding machines shall be capable of grinding the PCC curb without damaging adjacent curb, pavement, or other structures.

(B) Curb Grinding.

As directed by the Contract Documents, grind the curb at locations requiring the installation of wheel chair ramps. Remove the curb to the specified dimensions with a maximum deviation of one-half (½) inch. Avoid damaging adjacent pavement, curb, sidewalk, or other structures to remain without the written approval of the Engineer.

(C) Forms for PCC.

Forms shall be rigid, straight metal. The maximum deflection of forms shall not exceed one-eighth ($^1/_8$) inch in ten (10) feet when tested as a simple beam and subjected to a center load of one thousand seven hundred (1,700) pounds. Clean and oil forms before PCC placement.

The minimum length shall be ten (10) feet. The depth shall be equivalent to the design thickness at the edge of the PCC. Bolt additional forms to the top of a form to achieve additional depth. Use a minimum of three (3) anchors for each individual form.

Radius forms may be comprised of wood or metal. Wood radius forms shall be rigid and finished on the PCC side of the form. The rigidity of the radius forms shall be as needed to resist deformation under the PCC load. Anchor radius forms as necessary to maintain the shape of the radius.

Bed and join forms neatly and tightly to line and grade in a manner that resists movement. Do not place forms on pedestals to maintain proper grade. Remove and reset forms that vary more than one-eighth ($^1/_8$) inch in ten (10) feet from line or grade.

Using the edge of existing PCC as a form is acceptable provided the existing PCC has a smooth vertical face or a keyed face that is free of soil or other contaminants.

(D) Pre-formed Expansion Joints.

Construct pre-formed expansion joints at the locations indicated in the Contract Documents. Place the pre-molded joint filler across the transverse length of the pavement and extend from one (1) inch below the pavement surface to the bottom of the pavement. Maintain the position of the pre-molded joint filler in a manner acceptable to the Engineer. Shape the pre-molded joint filler to match the shape of the integral curb attached to the pavement.

After placing the PCC, place joint sealant atop the pre-molded joint filler to one-fourth (¼) inch below the pavement surface.

(E) Pressure Relief Joints.

Construct pressure relief joints at the locations indicated in the Contract Documents. The longitudinal width of the pressure relief joint shall be four (4) inches with an allowable deviation of one-fourth inch (¼) at the time of construction. The pressure relief joint shall extend throughout the full width and depth of the surrounding pavement.

The surrounding surfaces shall be dry and free of dirt, grease, or other contaminants. Install the pressure relief joint filler in accordance with the manufacturer's instructions.

(F) Placing Reinforcing Steel.

Place steel reinforcement as directed by the Contract Documents. Overlap adjacent sheets of wire fabric a minimum of twelve (12) inches. Keep sheets straight during and after installation. Tie lapped sheets using steel wire or other material acceptable to the Engineer. Tie longitudinal laps at a spacing of twenty-four (24) inches or less. Tie transverse laps at a spacing of forty-eight (48) inches or less.

Place the reinforcement a maximum of three (3) inches from a longitudinal construction or expansion joint and a maximum of a two (2) inches from a transverse construction or expansion joint. Place the reinforcement within one-fourth (¼) inch of the elevation required in the Contract Documents. Position the reinforcement before placing the PCC. Use metal supports acceptable to the Engineer to maintain the position of the reinforcement. Do not place any load on positioned reinforcement that causes the reinforcement to move out of position.

Maintain the position of the reinforcement before, during, and after PCC placement.

Place reinforcement mechanically using equipment designed and intended for this purpose and approved by of the Engineer. Mechanically placed reinforcement is subject to the positioning requirements for manually placed reinforcement.

(G) Placing PCC.

Before commencing PCC placement, adjust all appurtenances to the required grade and alignment or form the area around the appurtenance for adjusted later. Construct a PCC header sized and located as indicated in the Contract Documents. For colored PCC applications and imprinted applications, prepare a complete test sample of the PCC for approval by the Engineer before commencing construction of the colored or imprinted PCC.

Provide sufficient lighting for placement and finishing operations as instructed by the Engineer. Do not place PCC at night or in low-light conditions without the Engineer's permission.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of

construction joints to achieve a saturated surface-dry condition immediately before PCC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

For evaporation rates greater than two-tenths pounds per square feet per hour (0.2 lbs/ft^2/hr), take precautions against shrinkage cracking acceptable to the Engineer. Determine the evaporation rate in accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[3]

[3] Figure reprinted with written permission from ACI International.

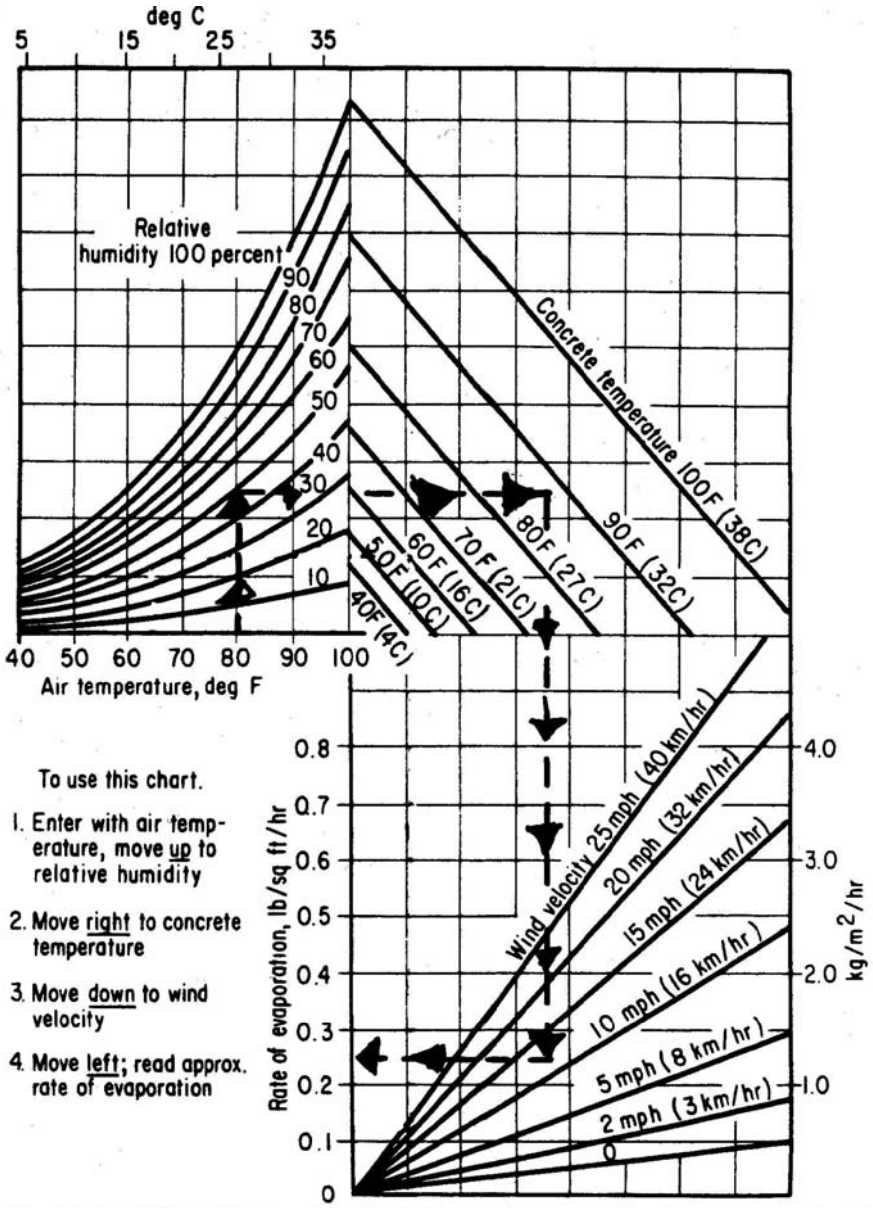

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

During cold weather periods, do not commence PCC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature

falls below forty (40) degrees Fahrenheit. Do not place PCC below the minimum allowable temperature without prior authorization by the Engineer. PCC placement below the minimum temperatures shall include all necessary measures to maintain the temperature of the PCC at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days. Do not place PCC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place the PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the PCC in a manner that minimizes segregation.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

After placing and before striking off, consolidate PCC using internal vibration provided by one (1) or more tube vibrators. Insert and immediately remove manual vibrators at regular intervals less than

three (3) feet apart. Do not drag manual vibrators through the PCC. Use machine-mounted vibrators in accordance with the manufacturer's recommendations. Use a tube vibrator when using a vibrating screed.

Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC.

At the completion of the placement or if the placement is interrupted by more than thirty (30) minutes, place a transverse construction joint extending the full width and depth of the placement. Locate the transverse construction joint in the placed PCC at the location of the closest joint indicated in the Contract Documents.

(H) Finishing, Curing, and Protecting PCC Pavement.

Strike off and finish the PCC to the elevation specified in the Contract Documents using a slip-form paver, rail-guided finishing machine, vibrating metal screed, or other mechanical equipment acceptable to the Engineer. Use a wooden screed only with the approval of the Engineer. Hand finish as necessary.

Remove material build-up from the forms before strike off or finishing begins. Vibrating screeds shall have a minimum weight of eight (8) pounds per linear foot and a minimum vibration frequency of three thousand five hundred (3,500) revolutions per minute at any point along the screed.

Operate the finishing equipment at a uniform speed in accordance with the manufacturer's recommendations. Adjust the speed of the finishing equipment if surface distressing occurs.

Immediately after mechanical finishing, true the surface using a ten (10) foot straightedge placed parallel and perpendicular to the direction of placement. Round the edges of the PCC surface using a one (1) inch diameter edging tool. Correct any irregularities in the surface and hand finish as needed.

Minimize screeding, floating, and troweling operations to avoid overworking or over-manipulation of the PCC. Remove any free water present on the PCC surface between finishing operations in a manner acceptable to the Engineer. Do not use neat cement or sand-cement mixtures to remove free water. Do not use finishing tools on PCC having free water present on the surface.

Apply an evaporation retardant acceptable to the Engineer to the surface as necessary. Minimize the amount of water added to the PCC surface to aid in finishing. Add an evaporation retardant or water by misting. Immediately remove excessive amounts of water as

determined by the Engineer in a manner acceptable to the Engineer. Do not conduct finishing operations if free water is present on the PCC surface.

Upon completion of the finishing operation, texture the PCC surface by a wet, double-burlap drag or broom-finish. Drag the burlap parallel to the placement direction. Broom-finish the surface uniformly and perpendicular to the placement direction. Mist water on the burlap to maintain adequate moisture in the burlap. Do not pressure spray water onto any burlap that is atop fresh PCC. Clean the burlap and brooms as needed to prevent build-up. Replace the burlap or broom if the build-up mars the PCC surface.

For imprint applications, apply the imprint form after the finishing operation and while the PCC surface is in a plastic stage. Apply the imprint forms perpendicular to the PCC edge or centerline.

Imprint the name of the Contractor and the year of construction into the unhardened PCC surface using a pre-fabricated stamp acceptable to the Engineer. Use block letters between one (1) and two (2) inches in height. The depth of the imprint shall be three-eighths (3⁄8) to one-half (½) inches. Imprint every one hundred (100) linear feet or as directed by the Engineer.

Within one (1) hour of PCC placement, protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer. Do not use liquid membrane-forming curing compounds for PCC base that will receive an ACP surface. Do not use asphalt emulsion for a curing material on PCC pavement, PCC overlay, or PCC surface repair. For colored PCC applications, thin the liquid curing compound in accordance with the manufacturer's instructions and apply at the application rate recommended by the manufacturer.

Apply PCC stains in accordance with the manufacturer's recommendations.

(I) Contraction Joints.

Saw or trowel longitudinal and transverse contraction joints at the dimensions and intervals indicated in the Contract Documents. For imprinted applications, locate the contraction joint to coincide with the lines of the imprint whenever possible. Use a straight, chalked line or other reference acceptable to the Engineer for guiding the line of the joint. Sawing shall begin as soon as the PCC has sufficiently hardened to allow sawing without tearing or raveling. Sequence the sawing to

prevent random cracking. Do not use early-entry saws without prior approval by the Engineer. Early entry saws shall cut a minimum of one-sixth ($^1/_6$) of the depth of the PCC, but not less than one (1) inch for any PCC thickness. Route random cracks to a minimum depth of one (1) inch and a maximum width of three-eighths ($^3/_8$) inch. Seal or apply curing compound to all contraction joints or routed cracks within twenty-four (24) hours of constructing or routing. Clean the contraction joints and routed cracks immediately before sealing operations. Place joint sealant in the sawed contraction joint and routed cracks to one-fourth (¼) inch below the pavement surface.

(J) Construction Joints.

Construct longitudinal and transverse construction joints to the dimensions indicated in the Contract Documents. Clean the construction joint immediately before sealing operations. Place joint sealant in the sawed construction joint to one-fourth (¼) inch below the pavement surface.

(K) Defective or Substandard PCC.

Remove and replace in accordance with the Contract Documents any portion(s) of the PCC placement that contains random cracking, plastic shrinkage cracking, scaling, high spots, depressions, or other defects or substandard conditions as determined by the Engineer. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

The maximum allowable deviation from plane is one-fourth (¼) inch in any ten (10) foot span. The maximum allowable deviation from the specified elevation is minus zero (-0), plus one-half (+½) inch provided the deviation does not alter the designed drainage pattern. The maximum allowable deviation for horizontal alignment is one (1) inch. The maximum allowable deviation for horizontal alignment at tie-in locations is one-half (½) inch.

Correct surface deviations by removing and replacing the non-complying section of PCC or by grinding the PCC using a diamond-tipped grinding wheel or other equipment satisfactory to the Engineer. Perform grinding in a manner that does not alter the designed drainage pattern or damage the structural soundness of the remaining PCC. Do not grind the PCC if the PCC will not meet elevation or thickness requirements after grinding. Correct any damage to the joint sealant in a manner acceptable to the Engineer.

Remove defective or substandard PCC to the nearest joint in all directions unless otherwise directed by the Engineer. At the discretion of the Engineer, route and seal random cracks or plastic shrinkage cracks in lieu of PCC removal and replacement.

(L) Opening PCC for Use.

Seal all joints before opening a section of PCC to traffic. Do not open a section until the PCC has reached a compressive strength of three thousand (3,000) psi. Determine the compressive strength in accordance with ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens. At the discretion of the Engineer, the compressive strength used for opening the pavement may be determined using ASTM C1074, Standard Practice for Estimating Concrete Strength by the Maturity Method as modified by the City of Omaha Materials Testing Manual for Public Works Construction.

(M) Requirements for Thickness.

Verify the thickness of the PCC by coring in accordance ASTM C174, Standard Test Method for Measuring the Thickness of Concrete Elements Using Drilled Concrete Cores. Deliver the cores to the Engineer for measurement.

503.04 Measurement and Payment.

The Engineer shall measure PCC sidewalk for payment by the total number of square feet of PCC sidewalk constructed and accepted.

The Engineer shall measure imprinted PCC sidewalk for payment by the total number of square feet of imprinted PCC sidewalk constructed and accepted.

The Engineer shall measure PCC median surfacing for payment by the total number of square feet of PCC median surfacing constructed and accepted.

The Engineer shall measure PCC mow strip for payment by the total number of square feet of PCC mow strip constructed and accepted.

The Engineer shall measure curb grinding for payment by the total number of linear feet of PCC curb ground and accepted. Wheelchair ramp construction is subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure PCC sidewalk repair for payment by the total number of square feet of PCC sidewalk repair constructed and accepted.

Perform any corrective action or removal and replacement activities at no additional cost to the City.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for removing existing sidewalk, forming, placing PCC, backfilling, and for all materials, forms, joint material, reinforcement, equipment, tools, labor and all incidentals necessary to complete the work.

Description	**Unit**
Concrete Sidewalk	Square Foot
___" Imprinted Concrete Sidewalk	Square Foot
Median Surfacing	Square Foot
Mow Strip	Square Foot
Grind Existing Curb For Wheel Chair Ramp	Linear Foot
Repair ___" Concrete Sidewalk	Square Foot

THIS PAGE INTENTIONALLY LEFT BLANK

504 – LOW STRENGTH CONCRETE

504.01 Description.

The work includes construction of surface or base course composed of low strength concrete (LSC) in accordance with these specifications and in conformity with the lines, grades, and cross sections indicated in the Contract Documents or established by the Engineer. The work includes removal or preparation of existing materials and replacement with LSC at the locations indicated in the Contract Documents or designated by the Engineer. In general, use LSC for a base course, temporary sidewalk, or other similar uses satisfied by a low strength rigid material.

504.02 Material Requirements.

(A) Portland Cement for LSC.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 2 (Maximum Equivalent Alkalies requirements only) and Table 3.

(B) Aggregate for LSC.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(C) Fly Ash for LSC.
Fly ash shall conform to the requirements of Class C Fly Ash as defined by ASTM C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.

(D) Water for LSC.
All water used in the LSC mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(E) Admixtures for LSC.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete, ASTM C1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete, or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the LSC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the LSC. Do not use any admixtures that retard the initial set of the LSC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(F) Curing Materials for LSC.

Curing materials shall be a liquid, membrane forming compound, polyethylene sheeting, or an asphalt emulsion. Liquid, membrane-forming compounds for curing LSC shall conform to the requirements for Type 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene sheeting for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete. Asphalt emulsion for curing LSC shall conform to the requirements for Type SS-1h as defined by ASTM D977, Standard Specification for Emulsified Asphalt.

(G) LSC Mix Proportioning and Required Properties.

Proportion LSC mixtures to meet the requirements of Table 504.01. Add the air-entraining admixture in a manner that will ensure uniform distribution of the agent throughout the batch. Base the air content of freshly mixed air-entrained LSC upon trial mixes with the materials to be used in the work adjusted to produce a mixture of the required plasticity and workability.

Table 504.01
LSC Properties

Property	Requirement
Portland Cement Content, lbs. per cu. yard.	282 min.
Cementitious Materials Content*, lbs. per cu. yd.	282 min.
Coarse Aggregate, % of Total Aggregate	0
Fine Aggregate, % of Total Aggregate	100
Maximum Water Cement Ratio	0.45
Minimum 28-Day Compressive Strength, psi	1500
Air Content, %	8.0±2.0
Slump, inches	5 max.
Maximum Freeze-Thaw Loss, %	14
Low strength concrete Temperature during placement, °F	70±20

*Total cementitious material equals Portland cement plus Class "C" Fly Ash

Referenced Test Procedures:

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM D560, Standard Test Methods for Freezing and Thawing Compacted Soil-Cement Mixtures
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

504.03 Construction Requirements.

(A) Equipment.

Mix the LSC materials using a central plant, truck mixer, or both. Batching and mixing equipment shall conform to the requirements of ASTM C94, Standard Specification for Ready-Mixed Concrete. Stockpile aggregates from different sources and of different grading separately. The mixer manufacturer shall indicate the recommended number of revolutions required on a manufacturer's serial plate attached to the mixer.

The production facility shall provide the batch information for each load of LSC delivered to the site. At a minimum, the batch information shall include the component materials, the actual batch weights and target batch weights of component materials, free moisture content of aggregates, water cement ratio of batch, and amount of additional water added at production facility after batching.

Paving machines shall be capable of spreading and striking off the necessary quantity of LSC. Spread the PCC uniformly and without segregation. Use hand operated or non-self-propelled screeds only with the approval of the Engineer. Protect adjacent materials and structures from paving machine tracks using cushions comprised of rubber or wood. Operate the paving machine at a steady pace that conforms to the manufacturer’s recommendations and provides a satisfactory finish.

Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer’s recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times. Use an internal tube vibrator whenever a vibrating screed is used.

Joint cutting saws shall use a water-cooled, diamond-tipped blade. Saws shall have an adjustable guide pointer. Keep a minimum of two

(2) operational saws on-site at all times. When approved, early-entry saws shall conform to the requirements of the Engineer. At a minimum, equip early-entry saws with an anti-ravel skid plate. Replace the anti-ravel skid plate as directed by the manufacturer.

Keep a sufficient number of ten (10) foot straightedges and a six (6) inch steel channel master straightedge with a minimum length of ten (10) feet on site at all times.

(B) Forms.

Forms shall be rigid, straight metal. The maximum deflection of forms shall not exceed one-eighth ($^1/_8$) inch in ten (10) feet when tested as a simple beam and subjected to a center load of one thousand seven hundred (1,700) pounds. Clean and oil forms before PCC placement.

The minimum length shall be ten (10) feet. The depth shall be equivalent to the design thickness at the edge of the pavement. Bolt additional forms to the top of a form to achieve additional depth. Use a minimum of three (3) anchors for each individual form.

Radius forms may be comprised of wood or metal. Wood radius forms shall be rigid and finished on the LSC side of the form. The rigidity of the radius forms shall be as needed to resist deformation under the LSC load. Anchor radius forms as necessary to maintain the shape of the radius.

Clean and oil forms before the placing of LSC. Set forms in advance of the LSC placement to ensure continuous paving operation. Bed and join forms neatly and tightly to line and grade in a manner that resists movement. Do not place forms on pedestals to maintain proper grade. Remove and reset forms that vary more than one-eighth ($^1/_8$) inch in ten (10) feet from line or grade.

Using the edge of existing PCC or LSC as a form is acceptable provided the existing PCC or LSC has a smooth vertical face or a keyed face that is free of soil or other contaminants.

(C) Placing LSC.

Before commencing LSC placement, adjust all appurtenances to the required grade and alignment or form the area around the appurtenance for later adjustment. Construct a header sized and located as indicated in the Contract Documents.

Provide sufficient lighting for placement and finishing operations as instructed by the Engineer. Do not place LSC at night or in low-light conditions without the Engineer's permission. The Contractor is responsible for any damage to the LSC due to weather conditions or other factors.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the LSC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for LSC material shall be five (5) feet. When desirable, place LSC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of LSC. Pumping and conveyor equipment shall permit LSC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final LSC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing LSC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of construction joints to achieve a saturated surface-dry condition immediately before LSC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before LSC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during LSC placement.

For evaporation rates greater than two-tenths pounds per square feet per hour (0.2 lbs/ft^2/hr), take precautions against shrinkage cracking acceptable to the Engineer. Determine the evaporation rate in accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[4]

[4] Figure reprinted with written permission from ACI International.

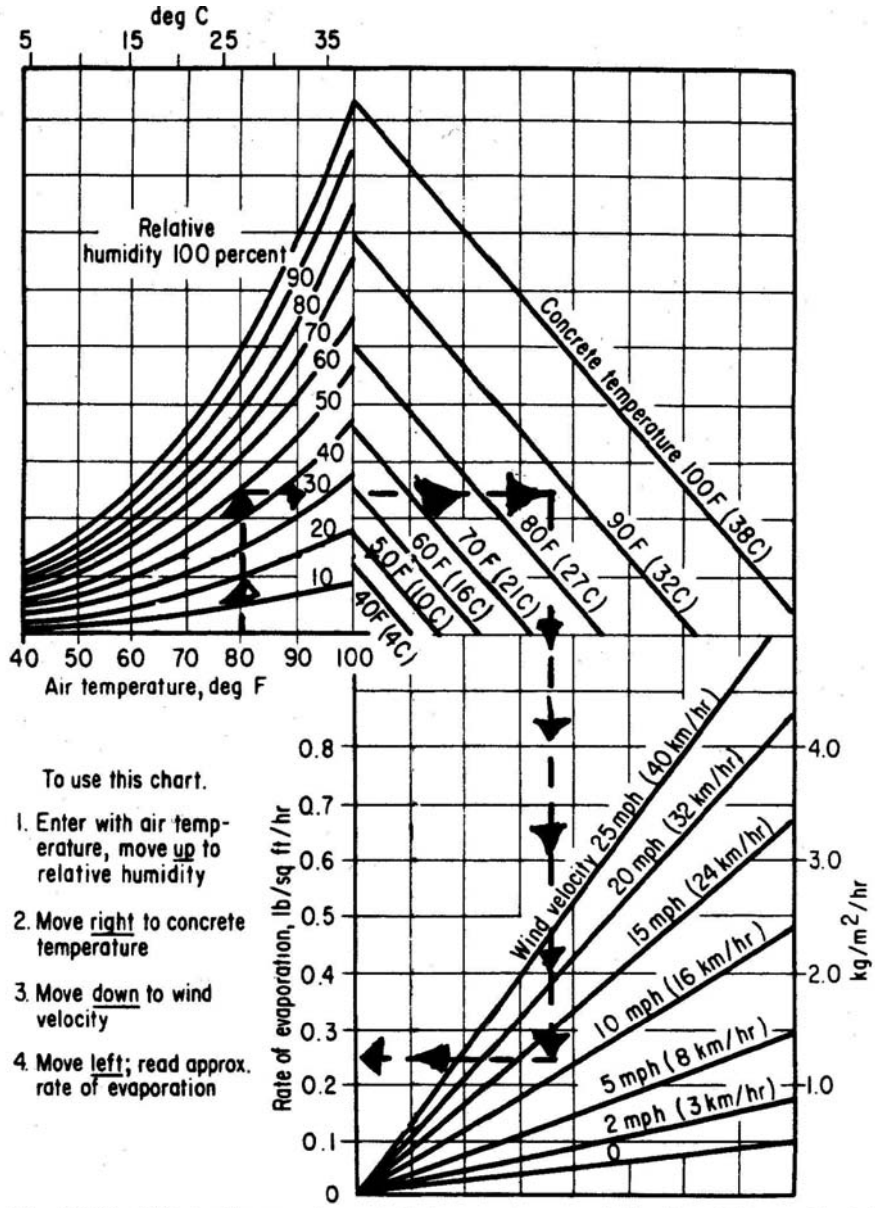

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

During cold weather periods, do not commence LSC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature

falls below forty (40) degrees Fahrenheit. Do not place LSC below the minimum allowable temperature without prior authorization by the Engineer. LSC placement below the minimum temperatures shall include all necessary measures to maintain the temperature of the LSC at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days. Do not place LSC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish LSC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh LSC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated LSC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place LSC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply LSC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the LSC material during conveyance. LSC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize LSC exposure to ambient conditions during conveying.

Provide concrete in a manner that provides constant, continuous supply of the LSC mixture. Deliver LSC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place LSC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the LSC in a manner that minimizes segregation.

Add water or admixtures to LSC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix LSC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing LSC discharge.

After placing and before striking off, consolidate the LSC using internal vibration provided by a tube vibrator. Insert and immediately remove manual vibrators at regular intervals less than three (3) feet

apart without dragging. Use machine-mounted vibrators in accordance with the manufacturer's recommendations. Do not use a vibrating screed in place of a tube vibrator.

Do not use vibration to move LSC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the LSC under their own weight. Do not force vibrators into semi-hardened LSC.

At the completion of the placement or if the placement is interrupted by more than thirty (30) minutes, place a transverse construction joint extending the full width and depth of the placement. Locate transverse construction joints in the placed LSC at the location of the closest joint indicated in the Contract Documents.

(D) Finishing, Curing, and Protecting the LSC Layer.

Strike off and finish the LSC using equipment and techniques acceptable to the Engineer. Use a slip-form paver, rail-guided finishing machine, vibrating metal screed, or other mechanical equipment acceptable to the Engineer to strike off and finish the LSC unless otherwise approved by the Engineer. Use a wooden screed only with the written permission of the Engineer. Hand finish as necessary.

Before commencing strike-off or finishing, remove any material or material build-up from the top of forms. Vibrating screeds shall have a minimum weight of eight (8) pounds per linear foot and a minimum vibration frequency of three thousand five hundred (3,500) revolutions per minute at any point along the screed.

Operate the finishing equipment at a uniform speed in accordance with the manufacturer's recommendations. Slow the speed of the finishing equipment if surface distressing occurs.

Immediately after mechanical finishing, true the surface using a ten (10) foot straightedge placed parallel and perpendicular to the direction of placement. Round the edges of the LSC surface using a one (1) inch diameter edging tool. Correct any irregularities in the surface and hand finish as needed.

Minimize screeding, floating, and troweling operations to avoid overworking or over-manipulation of the PCC. Remove any free water present on the LSC surface between finishing operations in a manner acceptable to the Engineer. Do not use neat cement or sand-cement mixtures to remove free water. Do not use finishing tools on LSC having free water present on the surface.

Apply an evaporation retardant acceptable to the Engineer to the surface as necessary. Minimize the amount of water added to the LSC surface to aid in finishing. Add an evaporation retardant or water by

misting. Immediately remove excessive amounts of water as determined by the Engineer in a manner acceptable to the Engineer. Do not conduct finishing operations if free water is present on the LSC surface.

Upon completion of the finishing operation, texture the LSC surface by a wet, double-burlap drag or broom-finish. Drag the burlap parallel to the placement direction. Broom-finish the surface uniformly and perpendicular to the placement direction. Mist water on the burlap to maintain adequate moisture in the burlap. Do not pressure spray water onto any burlap that is atop fresh LSC. Clean the burlap and brooms as needed to prevent build-up. Replace the burlap or broom if the build-up mars the LSC surface.

Within one (1) hour of PCC placement, protect the exposed, finished LSC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and maintain the LSC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer. Do not use liquid membrane-forming curing compounds for LSC base that will receive an ACP surface.

(E) Contraction Joints.

Saw longitudinal and transverse contraction joints at the dimensions and intervals indicated in the Contract Documents. Sawing shall begin as soon as the LSC has sufficiently hardened to allow sawing without tearing or raveling. Use a straight, chalked line or other reference acceptable to the Engineer for guiding the line of the saw. Sequence the sawing to prevent random cracking. Do not use early-entry saws without prior approval by the Engineer. Early entry saws shall cut a minimum of one-sixth ($^1/_6$) of the depth of the PCC, but not less than one (1) inch for any LSC thickness. Route random cracks to a minimum depth of one (1) inch and a maximum width of three-eighths ($^3/_8$) inch. Seal or apply curing compound to all contraction joints or routed cracks within twenty-four (24) hours of sawing or routing. Clean the contraction joints and routed cracks immediately before sealing operations. Place joint sealant in the sawed contraction joint and routed cracks to one-fourth (¼) inch below the pavement surface.

(F) Construction Joints.

Construct joints at a maximum spacing of fifty (50) feet by tooling the plastic mixture or by sawing the hardened LSC. The depth of the joint shall be one-sixth (1/6) of the thickness of the LSC layer. Apply curing compound to the construction joint immediately after joint construction.

(G) Defective or Substandard LSC.

Remove and replace in accordance with the Contract Documents any portion(s) of the LSC placement that contains random cracking, plastic shrinkage cracking, scaling, high spots, depressions, or other defects or substandard conditions as determined by the Engineer. The Contractor is responsible for any damage to the LSC due to weather conditions or other factors.

The maximum allowable deviation from plane is one-fourth (¼) inch in any ten (10) foot span. The maximum allowable deviation from the specified elevation is minus zero (-0), plus one-half (+½) inch provided the deviation does not alter the designed drainage pattern. The maximum allowable deviation for horizontal alignment is one (1) inch. The maximum allowable deviation for horizontal alignment at tie-in locations is one-half (½) inch.

Correct surface deviations by removing and replacing the non-complying section of LSC or by grinding the LSC using a diamond-tipped grinding wheel or other equipment satisfactory to the Engineer. Perform grinding in a manner that does not alter the designed drainage pattern or damage the structural soundness of the remaining LSC. Do not grind the LSC if the LSC will not meet elevation or thickness requirements after grinding. Correct any damage to the joint sealant in a manner acceptable to the Engineer.

Remove defective or substandard LSC to the nearest joint in all directions unless otherwise directed by the Engineer. At the discretion of the Engineer, route and seal random cracks or plastic shrinkage cracks in lieu of LSC removal and replacement.

(H) Opening LSC for Use.

Do not open the LSC to traffic until the LSC has reached a compressive strength of five hundred (500) psi. Determine the compressive strength in accordance with ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens. At the discretion of the Engineer, the compressive strength used for opening the pavement may be determined using ASTM C1074, Standard Practice for Estimating Concrete Strength by the Maturity Method as modified by the City of Omaha Materials Testing Manual for Public Works Construction.

(I) Requirements for Thickness.

Verify the thickness of the LSC by coring in accordance with ASTM C174, Standard Test Method for Measuring the Thickness of Concrete Elements Using Drilled Concrete Cores. Deliver cores to the Engineer for measurement.

504.04 Measurement and Payment.

The Engineer shall measure low strength concrete for payment by the total number of cubic yards of low strength concrete constructed and accepted.

Perform any corrective action or removal and replacement activities at no additional cost to the City.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Low Strength Concrete	Cubic Yard

THIS PAGE INTENTIONALLY LEFT BLANK

600 STRUCTURAL CONSTRUCTION

601 – BARRIER CURB

601.01 Description.

This work includes constructing and installing cast-in-place or precast PCC barrier curb, end, and transition sections along the lines and grades indicated in the Contract Documents or as directed by the Engineer.

601.02 Material Requirements.

(A) Portland Cement for PCC.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3. Do not use blended hydraulic cements without prior approval of the Engineer. Blended hydraulic cements shall conform to the requirements of ASTM C595, Standard Specification for Blended Hydraulic Cements.

(B) Water for PCC.
All water used in the PCC mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(C) Aggregate for PCC.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(D) Admixtures for PCC.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride

on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC. Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(E) Coloring Agent for PCC.

Coloring agent shall comply with the requirements of ASTM C979, Pigments for Integrally Colored Concrete. Add coloring agent in accordance with the manufacturer's recommendations. The maximum allowable dosage for a coloring agent is ten (10) percent of the total weight of cementitious materials.

(F) PCC Stain for PCC.

PCC stain shall be a waterborne, acrylic-based stain designed for the intended use and acceptable to the Engineer.

(G) PCC Mix Proportioning.

Proportion PCC mixtures to meet the requirements of Table 601.01.

Table 601.01
PCC Properties

Mix Type	L6
Portland Cement Content, lbs. per cubic yard	564 min.
Coarse Aggregate, % of Total Aggregate	30±3
Fine Aggregate, % of Total Aggregate	70±3
Maximum Water Cement Ratio	0.45
Minimum 28-Day Compressive Strength, psi	3500
Entrained Air Content, %	6.5±1.0
Slump, inches	1.5±1.5
PCC Temperature during placement, (°F)	70±20

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(H) Reinforcing Steel for PCC.

Reinforcing steel shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

(I) Curing Materials for PCC.

Curing materials shall be membrane-forming compounds or polyethylene film. Liquid, membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

(J) Precast Barrier Curb.

Precast barrier curb units shall conform to the requirements of the Contract Documents and ASTM C825, Standard Specification for Precast Concrete Barriers. The Engineer shall resolve any conflicts.

601.03 Construction Requirements.

(A) General.

Provide all equipment, labor, and tools necessary to perform the work to the satisfaction of the Engineer. The National Ready Mixed Concrete Association shall certify that the PCC production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

The production facility shall provide the batch information for each load of PCC delivered to the site. The batch information shall accompany each load delivered to the site. At a minimum, the batch information shall include the component materials, the actual batch weights and target batch weights of component materials, free moisture content of aggregates, water cement ratio of batch, and amount of additional water added at production facility after batching.

Slip-form machines shall be self-propelled and capable of uniformly placing, vibrating, and shaping the PCC without segregation. Protect

adjacent pavement from the slip-form machine tracks using cushions comprised of rubber or wood as directed by the Engineer. Operate the machine at a steady pace that conforms to the manufacturer's recommendations and provides a satisfactory finish.

Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

All equipment, tools, and machinery used in the work shall be adequate for the intended use. Maintain all equipment, tools, and machinery used in the work in a satisfactory working condition.

The Contractor may submit alternate barrier curb designs to the Engineer for approval before use. Alternate designs shall identify all differences in the casting, reinforcing, attachments, or holes for lifting and handling. Alternate designs shall meet or exceed the performance requirements of the barrier curb design indicated in the Contract Documents. Do not commence manufacture of alternately designed barrier curb sections without written approval of the Engineer.

(B) Forms for PCC.

Use forms comprised of metal, wood, or other material acceptable to the Engineer. Do not use forms comprised of aluminum. Forms shall be mortar-tight, produce a uniform surface texture and appearance acceptable to the Engineer, and be sufficiently rigid to prevent distortion due to pressures of PCC, vibration, and other loads associated with construction operations. Joints shall be tight and cut smooth. Wood forms shall be finished on the PCC side of the form and maintained to prevent warping and opening of joints due to shrinkage of lumber. Align consecutive wood forms to match the joints and grain of the wood. Use the same form material for all PCC barrier curb constructed on the project unless otherwise approved by the Engineer in writing. Do not re-use forms or form materials failing to satisfy any shape, strength, rigidity, mortar tightness, or surface smoothness requirements. Do not use warped or bulged lumber.

Design the forms to permit removal of any ties or anchors contained within the forms to a minimum depth of one (1) inch beneath the surface of the PCC without injury to the PCC.

Bed and join forms neatly and tightly to line and grade in a manner that resists movement. Do not place forms on pedestals to maintain proper grade. Remove and reset forms that vary more than one-fourth (¼) inch in ten (10) feet from line or grade. Remove any dirt, sawdust, or other extraneous materials from the forms before placing the PCC. Treat form surfaces with form oil or other material acceptable to the

Engineer that prevents bonding of the PCC to the form. Such material shall not adhere to or discolor the PCC surface.

(C) Placing Reinforcing Steel.

Place steel reinforcement as directed by the Contract Documents. Place the reinforcement within one-fourth (¼) inch of the elevation required in the Contract Documents. Position the reinforcement before placing the PCC. Use metal supports or other mechanisms acceptable to the Engineer to maintain the position of the reinforcement. Do not place any load on positioned reinforcement that causes the reinforcement to move out of position. Maintain the position of the reinforcement before, during, and after PCC placement.

(D) PCC Placement.

Provide sufficient lighting for placement and finishing operations as instructed by the Engineer. Do not place PCC at night or in low-light conditions without the Engineer's permission. For colored PCC applications and imprinted applications, prepare a complete test sample of the PCC for approval by the Engineer before commencing construction of the colored or imprinted PCC.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of

construction joints to achieve a saturated surface-dry condition immediately before PCC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

For evaporation rates greater than two-tenths pounds per square feet per hour (0.2 lbs/ft^2/hr), take precautions against shrinkage cracking acceptable to the Engineer. Determine the evaporation rate in accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[5]

[5] Figure reprinted with written permission from ACI International.

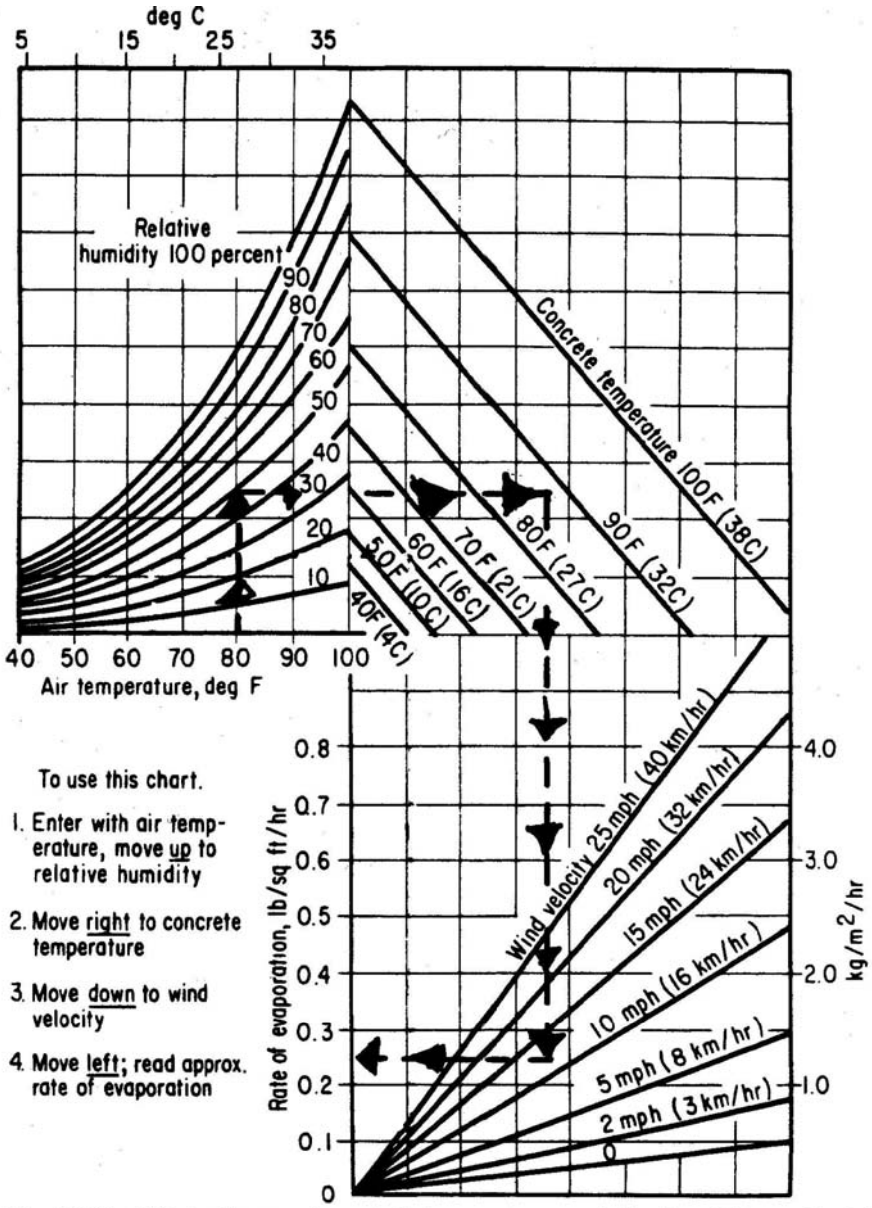

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

During cold weather periods, do not commence PCC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature

falls below forty (40) degrees Fahrenheit. Do not place PCC below the minimum allowable temperature without prior authorization by the Engineer. PCC placement below the minimum temperatures shall include all necessary measures to maintain the temperature of the PCC at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days. Do not place PCC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the PCC in a manner that minimizes segregation.

Use chutes and/or pipes to convey PCC from the mixer or transport vehicle to the forms. Use chutes and pipes comprised of metal or metal lined with plastic, rubber, or other non-deteriorating material acceptable to the Engineer. Equip steep chutes with baffle boards or use short sections that reverse the direction of movement. Extend chutes or pipes inside the forms or through holes left in the form as necessary. Do not allow the PCC to drop a distance greater than five (5) vertical feet. Remove any hardened PCC or other debris before using chutes and pipes. Adjust the chute or pipe discharge ends to facilitate proper PCC placement.

Place the PCC in continuous horizontal layers having a maximum thickness of twenty (20) inches unless otherwise indicated in the Contract Documents or approved by the Engineer. Deposit PCC in each part of the forms as near to the final position as possible.

Consolidate the PCC under and around the reinforcement bars without displacing them. Stop monolithic placements at a vertical bulkhead. Avoid spattering forms or reinforcement bars with PCC when such spattering may harden before incorporation into the mass. Regulate PCC placement to prevent the fluid PCC pressure from exceeding the values used in designing the forms.

Place PCC using pumping equipment as necessary. Use equipment that has sufficient capacity and is acceptable to the Engineer. Do not use components comprised of aluminum or aluminum alloy to convey the PCC. Pumping equipment shall introduce, transport, and discharge the PCC continuously without segregating or introducing air pockets into the material. Do not place the PCC materials used to prime the pumping equipment. Waste such material until the PCC discharged is uniform with the other material in the pumping system as determined by the Engineer. Perform all testing on PCC material after discharging the material from the pumping equipment.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

After placing and before striking off, consolidate PCC using internal vibration provided by one (1) or more tube vibrators. Insert and immediately remove manual vibrators at regular intervals less than three (3) feet apart. Do not drag manual vibrators through the PCC. Use machine-mounted vibrators in accordance with the manufacturer's recommendations. Use a tube vibrator for all formed placements. Place and consolidate each layer before the preceding layer has taken initial set to prevent injury to the fresh PCC and avoid surfaces of separation between layers. Finish all PCC surfaces not contained within the forms in a manner acceptable to the Engineer.

Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC.

Minimize screeding, floating, and troweling operations to avoid overworking or over-manipulation of the PCC. Remove any free water present on the PCC surface between finishing operations in a manner

acceptable to the Engineer. Do not use neat cement or sand-cement mixtures to remove free water. Do not use finishing tools on PCC having free water present on the surface.

Apply an evaporation retardant acceptable to the Engineer to the surface as necessary. Minimize the amount of water added to the PCC surface to aid in finishing. Add water only by misting. Immediately remove excessive amounts of water as determined by the Engineer in a manner acceptable to the Engineer. Do not conduct finishing operations if free water is present on the PCC surface.

Within one (1) hour of PCC placement, protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer. For colored PCC applications, thin the liquid curing compound in accordance with the manufacturer's instructions and apply at the application rate recommended by the manufacturer.

Apply PCC stains in accordance with the manufacturer's recommendations.

Remove all dried PCC particles and any other objectionable material from the face of the PCC placement before resuming any placement temporarily interrupted by less than thirty (30) minutes. At the completion of the placement or if the placement is interrupted by more than thirty (30) minutes, place a transverse construction joint extending the full width and depth of the placement. Locate the transverse construction joint in the placed PCC at the location of the closest joint indicated in the Contract Documents. Remove any PCC accumulations from exposed reinforcement without incorporating such accumulations into the fresh PCC or damaging hardened PCC or the PCC-reinforcement bond.

(E) Form Removal.

Remove forms as soon as practicable and safe to permit the required surface finishing. Remove any blocks or bracing with the forms. Do not use removal methods that in the opinion of the Engineer may overstress or otherwise damage the PCC. Do not partially remove any forms without approval by the Engineer. Do not remove forms when the ambient temperature is less than forty (40) degrees Fahrenheit without protecting the exposed PCC surface in a manner acceptable to the Engineer. Immediately following the removal of forms, remove all fins and irregular projections from all exposed surfaces.

Repair any cavities, holes, honeycomb spots, broken corners or edges, and other defects by cleaning, saturating with water, and filling with a non-shrinking grout or mortar. Finish the grout or mortar to obtain a sound, smooth, and uniform surface. Finish the grout to obtain a sound, smooth, and uniform surface. Remove the protruding ends of plastic ties flush with the PCC surface.

(F) Joints.

Joints shall be square and normal to the barrier curb. Finish the face edges of all exposed joints true to line and elevation. Locate joints as indicated in the Contact Documents or as directed by the Engineer. Check the form tightness before depositing new PCC on or against hardened PCC. Clean the hardened PCC surface and remove any loose particles or damaged portions of the hardened PCC. Saturate the hardened PCC with water before placing fresh PCC.

(G) Defective or Substandard PCC.

Remove and replace in accordance with the Contract Documents any portion(s) of the PCC placement that contains random cracking, plastic shrinkage cracking, scaling, spalls, honeycombs, high spots, depressions, or other defects or substandard conditions as determined by the Engineer. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

The maximum allowable deviation from plane is one-half (½) inch in any ten (10) foot span. The maximum allowable deviation from the specified elevation is minus zero (-0), plus one-half (+½) inch. The maximum allowable deviation for horizontal alignment is one (1) inch. The maximum allowable deviation for horizontal alignment at tie-in locations is one-half (½) inch.

(H) Precast Barrier Installation.

Store and handle precast units without cracking or damaging the units. Replace any damaged precast barrier curb units at no additional cost to the City. Repair minor chips, spalls, and sears only with the approval of the Engineer. Seal all lift slots and dowel holes by cleaning, saturating with water, and filling with a non-shrinking grout or mortar.

601.04 Measurement and Payment.

The Engineer shall measure barrier curb for payment as a single unit defined by the number of linear feet of PCC barrier curb supplied, constructed, and accepted. Barrier curb supplied for temporary use will not be measured separately and shall be considered subsidiary to items for which the Contract provides direct payment. Replace any damaged precast barrier curb units at no additional cost to the City.

The Engineer shall measure barrier curb end sections for payment as a single unit defined by the number of PCC barrier curb end sections supplied, constructed, and accepted.

The Engineer shall measure barrier curb transition sections for payment as a single unit defined by the number of PCC barrier curb transition sections supplied, constructed, and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for the cost for all forming, PCC placement, reinforcement, and dowel bars; for transporting and placing if precast units are utilized; for all grouting; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
PCC Barrier Curb	Linear Foot
PCC Barrier Curb End Section	Each
PCC Barrier Curb Transition Section	Each

602 – SHEET PILING

602.01 Description.

This work includes supplying and installing sheet piling along the lines and grades indicated in the Contract Documents or as directed by the Engineer.

602.02 Material Requirements.

Sheet pile and sheet pile corners shall conform to the requirements of ASTM A328, Standard Specification for Steel Sheet Piling.

602.03 Construction Requirements.

Using equipment designed and having adequate capacity to perform the work, drive sheet piles to the required elevation or until obtaining practical refusal above the required elevation as accepted by the Engineer. Install sheet piles in the required position and plumb or to the batter indicated in the Contract Documents or as directed by the Engineer. The maximum allowable variation from vertical or batter line indicated shall be two (2) percent. The maximum allowable deviation from positioning at the top of the sheet pile shall be two (2) inches. The maximum allowable deviation from line for adjacent sheet pile tops shall be one (1) inch. Remove and replace any broken, split, or improperly installed sheet piles. At the discretion of the Engineer, broken, split, or improperly installed sheet piles may remain in-place with the installation of a second sheet pile at the proper position and batter.

Remove and replace sheet pile driven below the required elevation. The Engineer reserves the right to allow such sheet piles to remain in-place with a full splice and extension installed.

Correct or remove and replace any previously driven sheet pile vertically displaced during installation of subsequent sheet piles.

602.04 Measurement and Payment.

The Engineer shall measure sheet pile for payment on a lump sum basis.

Unless otherwise indicated in the Contract Documents, sheet pile supplied and installed for temporary use will not be measured separately and shall be considered subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for splices, extensions, and all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Sheet Pile	Lump Sum

603 – BOX CULVERTS

603.01 Description.

This work includes cleaning, relocating, or constructing box storm drains and culverts including excavation, backfill, and other related items along the lines and grades indicated in the Contract Documents or as directed by the Engineer.

603.02 Material Requirements.

(A) Aluminum Box Culverts, Fittings, and Outlet Structures.
Aluminum box culverts shall conform to the requirements of ASTM B864, Standard Specification for Corrugated Aluminum Box Culverts.

(B) Steel Box Culverts, Fittings, and Outlet Structures.
Steel box culverts shall conform to the requirements of ASTM A964, Standard Specification for Corrugated Steel Box Culverts.

(C) Precast Reinforced PCC Structures, Box Culverts, Fittings, and Outlet Structures.
Precast reinforced PCC box sections shall conform to the requirements of ASTM C1433, Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers. Three-(3) sided precast PCC structures shall conform to the requirements of ASTM C1504, Standard Specification for Manufacture of Precast Reinforced Concrete Three-Sided Structures for Culverts, Storm Drains, and Sewers.

(D) Aggregate Bedding Material.
Aggregate bedding material shall consist of recycled PCC, crushed limestone, quartzite, or dolomite meeting the requirements for Class 1S coarse aggregate as defined by ASTM C33, Standard Specification for Concrete Aggregates. The aggregate shall be well-graded with a maximum of eight (8) percent of the material passing a #200 (75 µm) standard sieve and a nominal maximum size of two (2) inches.

(E) Portland Cement for PCC.
Portland cement for use with storm sewer applications shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3. Do not use blended hydraulic cements without prior approval of the Engineer. Blended hydraulic cements shall conform to the requirements of ASTM C595, Standard Specification for Blended Hydraulic Cements.

Portland cement for use with sanitary or combined sewer applications shall conform to the requirements for Cement Type I or Cement Type

II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2, and Table 3. The maximum tricalcium aluminate content shall not exceed eight (8) percent

(F) Aggregate for PCC and Flowable Fill.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete Aggregates.

(G) Fly Ash for Flowable Fill.
Fly ash shall conform to the requirements of Class C Fly Ash as defined by ASTM C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.

(H) Water for PCC and Flowable Fill.
Water shall conform to the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(I) Admixtures for PCC and Flowable Fill.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC. Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(J) Flowable Fill Mix Proportioning and Required Properties.
Prepare and submit a flowable fill mix design that identifies the component materials, the proportion of such materials, the twenty-eight (28) day compressive strength, and the air content. Flowable fill shall have a twenty-eight (28) day compressive strength of seventy-five plus or minus fifty (75±50) pounds per square inch and an air content of ten plus or minus three (10±3) percent. Proportion the materials to produce a mixture with a consistency that flows under a very low head.

(K) PCC Mix Proportioning and Required Properties.
Proportion PCC mixtures to meet the requirements of Table 603.01. Do not use fly ash in the PCC mixture. Manufacture the PCC in accordance with ASTM C94, Standard Specification for Ready-Mixed Concrete.

Table 603.01
PCC Properties

Mix Type	L6	L6M
Portland Cement Content, lbs. per cubic yard	564 min.	564 min.
Coarse Aggregate, % of Total Aggregate	30±3	30±3
Fine Aggregate, % of Total Aggregate	70±3	70±3
Maximum Water Cement Ratio	0.45	0.45
Minimum 28-Day Compressive Strength, psi	3500	3500
Air Content, %	6.5±1.0	6.5±1.0
Slump, inches	2.5±1.5	2.5±1.5
PCC Temperature during placement, °F	70±20	70±20

Referenced Test Procedures:

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(L) Reinforcement for PCC.
Welded wire fabric shall conform to the requirements of ASTM A185, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement. Steel bars shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

Keep reinforcing metal clean and free of rust or foreign material. Protect reinforcing materials from weather until placement. Supply and store welded wire sheets and welded bar mats in flat sheets.

(M) Curing Materials for PCC.

Curing materials shall be membrane-forming compounds or polyethylene film. Liquid membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

603.03 Construction Requirements.

(A) Excavation.

Excavate the channel and footings to the outline and elevations indicated in the Contract Documents or as established by the Engineer including any additional excavation necessary for constructing the box culvert. Do not round or undercut footing corners or edges. Smooth the footing bed to conform to the lines, grades, and dimensions of the footings. The Engineer reserves the right to alter the bottom elevation of the footings as necessary to satisfy changes in dimensions and/or footing elevations or to place the footing on satisfactory soils. Additional footing excavation is incidental to the work.

Protect excavations in accordance with the requirements of 29CFR Part 1926, Safety and Health Regulations for Construction. Provide all sheathing, bracing, piling, and shoring necessary to protect the excavation and all adjacent structures. Any damage to the work or to adjacent structures resulting from failure of excavation walls will be the Contractor's responsibility. Do not excavate beyond the bottom elevation indicated in the Contract Documents of any footings, walls, floors, etc., of an adjacent structure without written approval from the Engineer.

Accomplish excavating in a manner that does not create collected or standing water at any place on the site during construction. The excavation shall be wide enough to allow thorough tamping of the backfill adjacent to the lower portion of the structure. The minimum width shall be two (2) feet wider than the maximum horizontal width of the structure. Over-excavate a minimum of six (6) additional inches below the lower surface of the structure when encountering a rock ledge. Replace the over-excavated material using crushed rock bedding to eliminate any part of the structure from resting on the rock ledge.

When footing excavations encounter a solid rock bottom, expose and prepare the solid rock in horizontal or properly serrated beds for

receiving PCC as allowed by the Engineer. Clean and grout seams or crevices. Remove loose or disintegrated rock and thin strata. Do not disturb the excavated surface where the Contract Documents indicate that PCC shall rest on excavated surface other than rock. Perform final preparation activities immediately before placing the PCC on the footing bed.

Over-excavate below the lower surface of the structure when the Engineer determines that the soils encountered will not provide adequate support for the structure. Over-excavate to a width and depth as determined by the Engineer. Do not excavate below the depths indicated. Replace over-excavated material to the established elevation using crushed rock compacted to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).

De-water the excavation whenever encountering a water-bearing stratum. De-water the excavation by draining, pumping, bailing, or other methods approved by the Engineer to an elevation below the elevation of the structure bottom and footing. Maintain the excavation as dry as possible or practicable during the placing and hardening of the PCC. Do not allow flowing water to contact unhardened PCC.

Design and construct cofferdams or cribs as necessary to complete the culvert construction and prevent damage to the foundation and unhardened PCC. Cofferdams and cribs shall extend below the bottom of the structure and footings and shall be well-braced and as watertight as practicable. Do not allow any portion of the cofferdam or crib to interfere, contact, or provide excessive loading on the structure. Remove cofferdams, cribs, and related components upon completion of the structure. Remove any obstructions to the flowline of the channel created by the Contractor's operations as directed by the Engineer. Dispose of any excess excavated material at a location acceptable to the Engineer.

(B) Bedding.

Bed all structures in accordance with the manufacturer's recommendations. Bedding shall consist of soil bedding or aggregate bedding. Soil bedding shall consist of shaping the bottom of the excavation to match the bottom of the structure. Spread a one (1) to two (2) inch layer of pulverized soil or fine gravel across the bottom of the trench. Aggregate bedding material shall extend the full width of the excavation and to a height as directed by the structure manufacturer, the Contract Documents, or the Engineer. Place the aggregate bedding material in six (6) inch maximum lifts compacted to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Standard Test Methods for Laboratory

Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).

(C) Precast and Manufactured Structure Installation and Reinstallation.

Install precast and manufactured structures at the locations and elevations indicated in the Contract Documents or as directed by the Engineer. Handle and store all culverts designated for reinstallation in a manner that avoids damaging the culvert. Identify and notify the Engineer immediately of any damaged culverts before removal. Reinstall any removed and relocated culverts after cleaning. Cleaning shall include removal of all soils, debris, and other build-up from the interior and exterior of the culvert. Inspect the culvert after cleaning before reinstallation. Replace any culverts damaged due to the Contractor's action with a similar sized and type of culvert at no additional cost to the City.

Install aluminum culverts in accordance with the requirements of ASTM B788, Standard Practice for Installing Factory-Made Corrugated Aluminum Culverts and Storm Sewer Pipe, or ASTM B789, Standard Practice for Installing Corrugated Aluminum Structural Plate Pipe for Culverts and Sewers.

Install precast PCC culverts in accordance with ASTM C1479, Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations.

Install steel culverts in accordance with ASTM A798, Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications, or ASTM A807, Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications.

Assemble manufactured structures in accordance with the manufacturer's instructions. Handle and place the structures in a manner that avoids damaging the structure, adjacent structures, excavation walls, or bedding material. Inspect the structures for damage or defects before commencing installation. Replace any damaged or defective structures at no additional cost to the City. Install structures only when weather and soil conditions are suitable. Prevent water and foreign matter from entering the structures, extensions, and adjacent pipe. Take all measures necessary to prevent water from filling the excavation and conduct operations in a manner that prevents culvert floatation. Brace or anchor the structure to prevent displacement after establishing final position.

(D) PCC Cast-in-Place Structure Construction.

Provide sufficient lighting for placement and finishing operations as instructed by the Engineer. Do not place PCC at night or in low-light

conditions without the Engineer's permission. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

The National Ready Mixed Concrete Association shall certify that the PCC production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

The PCC production facility shall provide the batch information for each load of PCC delivered to the site. The batch information shall accompany each load delivered to the site. At a minimum, the batch information shall include the component materials, the actual batch weights and target batch weights of component materials, free moisture content of aggregates, water cement ratio of batch, and amount of additional water added at production facility after batching.

Forms may be comprised of wood or metal. Wood forms shall be rigid and finished on the PCC side of the form. The rigidity of the forms shall be as needed to resist deformation under the PCC load. Anchor forms as necessary to maintain shape. Support forms to prevent movement of the forms during curing of the PCC. The Engineer reserves the right to reject structures damaged by movement of the forms. Clean and oil forms before PCC placement. Bed and join forms neatly and tightly to line and grade in a manner that resists movement. Do not place forms on pedestals to maintain proper grade. Remove and reset forms that vary more than one-fourth (¼) inch from line or grade.

Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

Place steel reinforcement as directed by the Contract Documents. Place the reinforcement within one-fourth (¼) inch of the elevation required in the Contract Documents. Position the reinforcement before placing the PCC. Use metal supports acceptable to the Engineer to maintain the position of the reinforcement. Do not place any load on positioned reinforcement that causes the reinforcement to move out of position. Maintain the position of the reinforcement before, during, and after PCC placement. Overlap adjacent sheets of wire fabric a minimum of twelve (12) inches. Keep sheets straight during and after installation. Tie lapped sheets using steel wire or other material acceptable to the

Engineer. Tie longitudinal laps at a spacing of twenty-four (24) inches or less.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of construction joints to achieve a saturated surface-dry condition immediately before PCC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

For evaporation rates greater than two-tenths pounds per square feet per hour (0.2 lbs/ft^2/hr), take precautions against shrinkage cracking acceptable to the Engineer. Determine the evaporation rate in accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[6]

[6] Figure reprinted with written permission from ACI International.

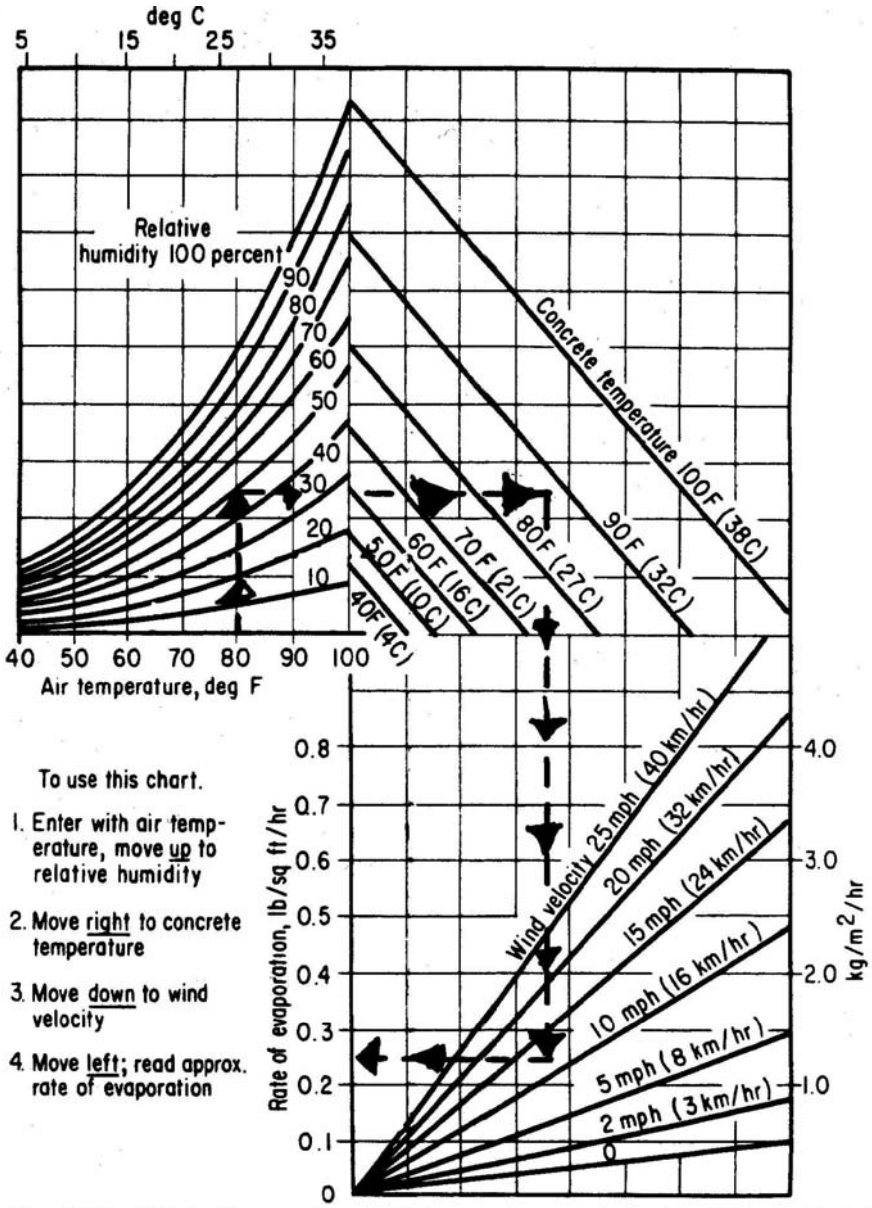

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

During cold weather periods, do not commence PCC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature

falls below forty (40) degrees Fahrenheit. Do not place PCC below the minimum allowable temperature without prior authorization by the Engineer. PCC placement below the minimum temperatures shall include all necessary measures to maintain the temperature of the PCC at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days. Do not place PCC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place the PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the PCC in a manner that minimizes segregation.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

After placing and before striking off, consolidate all portions of the PCC to eliminate trapped air pockets using a tube vibrator. Insert and

immediately remove manual vibrators at regular intervals less than three (3) feet apart without dragging.

Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC.

Strike off and finish the PCC to the elevation specified in the Contract Documents using tools and techniques acceptable to the Engineer. Protect all cast-in-place PCC from freezing and loss of moisture for a minimum of twenty-four (24) hours after construction using curing materials and methods acceptable to the Engineer.

Within one (1) hour of PCC placement, protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer. Do not use liquid membrane-forming compounds on any surface to be damp-proofed.

Upon removal of the forms, fill and seal all holes, honeycombed sections, and joints with joint mortar. Apply a damp-proof coating consisting of a primer and damp-proofing material to the non-exposed surfaces of the PCC retaining wall as directed by the Engineer. Limit all damp-proofing materials to the treated areas. Do not disfigure untreated portions of the stairs with damp-proofing materials. Uniformly apply one (1) coat of primer and two (2) coats of damp-proofing material in accordance with the manufacturer's instructions. Perform damp-proofing in dry weather when the ambient temperature is forty (40) degrees Fahrenheit or above. Allow each coating to dry before applying the next coating in accordance with the manufacturer's recommendations. Allow the damp-proofing to cure in accordance with the manufacturer's recommendations before commencing backfilling operations.

(E) Defective or Substandard PCC.

Remove and replace in accordance with the Contract Documents any portion(s) of the PCC placement that contains random cracking, plastic shrinkage cracking, scaling, high spots, depressions, or other defects or substandard conditions as determined by the Engineer. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

(F) Soil Backfill.

Inspect the structures before commencing backfilling operations to verify that the structures are undamaged, in the proper alignment, and have not settled. In a manner acceptable to the Engineer, repair or remove and replace any structure that has settled or become damaged or out-of-alignment at no additional cost to the City. Do not backfill cast-in-place PCC structures until the PCC has a minimum compressive strength of three thousand (3,000) pounds per square inch. Avoid damaging any damp-proofing coating during backfilling. Immediately repair any damage to the damp-proof coating without additional cost to the City.

Backfill excavations, abutments, wingwalls, and structures using soil, granular material, or other materials acceptable to the Engineer. Supply additional material as necessary to complete the backfill. All additional material is subject to approval by the Engineer.

Place the backfill material evenly on each side of the structure and uniformly across the excavation. Place backfill within six (6) inches of drain or weep holes without covering or otherwise blocking the drain or weep holes. Backfill material shall not contain frozen lumps, stones greater than two (2) inches in diameter, chunks of highly plastic clay, or other objectionable material unless approved by the Engineer in writing. Using equipment and methods acceptable to the Engineer, compact the backfill uniformly in lifts not exceeding six (6) inches in compacted thickness without damaging the structure or adjacent structures. Do not use jetting to expedite settlement of backfill. Do not dump materials over the ends of culverts or dump directly against a structure, abutment, or wingwall.

The completed backfill shall not yield under repeated loading by heavy trucks or equipment. Construct the backfill to meet the requirements of Table 603.02. The maximum dry density (Standard Effort) and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). The maximum dry density (Modified Effort) and optimum moisture shall be determined by ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

Table 603.02
Backfill Requirements

Depth Below Pavement or Finished Grade	Minimum Compaction Requirement	Acceptable Moisture Range
≤ 1 foot (under pavement and within 4 feet of the edge of pavement and under sidewalk/ bike trail)	90% of Maximum Dry Density (**Modified** Effort)	Optimum Moisture Content –3%, +4%
≤ 1 foot (beyond 4 ft of pavement or beyond edge of sidewalk / bike trail)	92% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%
Greater than 1 foot (all locations)	95% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%

Manipulate, intermix with borrow materials, or replace with borrow materials any existing materials having a moisture content outside the acceptable range. Continue backfilling operations until the top of the backfill is even with the adjacent ground surface. Place topsoil in the upper six (6) inches for locations outside the limits of pavement construction unless otherwise directed by the Engineer. When requested by the Engineer, expose select locations for compaction and moisture content testing. Exposing such locations is incidental to the work. Rework or remove and replace any materials that do not comply with the above requirements.

(G) Flowable Fill Backfill.

The National Ready Mixed Concrete Association must certify the flowable fill production facility. Mixing times shall conform to the requirements of ASTM C94, Specification for Ready-Mixed Concrete. Hand mixing is not allowed. The production facility shall supply a load ticket with the actual batch weights of component materials. Inspect the pipe before commencing backfilling operations to verify that all pipes have not settled and are undamaged and in the proper alignment. Remove and relay any culverts that have settled or become damaged or out-of-alignment at no additional cost to the City. Do not backfill PCC encasements or collars until the PCC has a minimum compressive strength of three thousand five hundred (3,500) pounds per square inch.

Thoroughly mix all water added at the project site in accordance with the recommendations stated in ACI 305, Hot Weather Concreting. Measure all water added to the mix. Do not exceed the water cement ratio stated in the flowable fill mix design approved by the Engineer. Do not add water after discharge of the flowable fill from the mixer has begun.

Place flowable fill within ninety (90) minutes after the addition of cement or fly ash to the mix. The Engineer reserves the right to reduce

the allowable time for placement to account for adverse weather conditions or other factors that may accelerate the stiffening of the mix.

603.04 Measurement and Payment.

The Engineer shall measure box culverts for payment as a single unit defined as the number of linear feet of each size and type of box culvert supplied, constructed, and accepted. The Engineer shall conduct measurements along the centerline of the floor of the box culvert from the start of the box culvert to end of box culvert excluding any wingwalls, cut-off walls, or other inlet or outlet structures. Inlet or outlet structures, including wing walls, cut-off walls, etc. will not be measured separately and shall be considered subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure the removal and reinstallation of existing culverts for payment as a single unit defined as the number of linear feet of each size and type of existing culvert removed, cleaned, reinstalled, and accepted. The Engineer shall conduct measurements along the centerline of the flowline of the culvert from the start of the culvert to the end of the culvert excluding any wingwalls or other inlet or outlet structures. The Engineer shall not measure inlet or outlet structures, including wing walls, cut-off walls, etc., separately and such items are subsidiary to items for which the Contract provides direct payment.

Replace unnecessary over-excavation at no additional cost to the City. Unless otherwise indicated in the Contract Documents, all costs associated with excavation and/or over-excavation for installation of the structure; protection of an excavation; de-watering; cofferdams or cribs; supplying additional material for completion of backfilling operations; manipulation of existing materials; intermixing of existing materials with borrow materials, and/or replacing existing materials with borrow materials are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for furnishing and placing reinforcing steel; for excavation, backfill, iron castings and other component materials; for the disposal of surplus excavated materials; for cleaning, relocating and installation; and for all forms, equipment, tools and incidentals necessary to complete the work.

Description	**Unit**
___ Box Culvert	Linear Foot
Remove and Reinstall ___ Culvert	Linear Foot

604 – GUARDRAIL

604.01 Description.

This work includes furnishing and erecting or removing and resetting cable, beam, safety beam, beam-type barrier, and safety beam-type barrier guardrail including guard posts at locations indicated in the Contract Documents or as directed by the Engineer. Beam guardrail and beam-type barrier guardrail shall consist of rigid beam elements bolted directly to treated timber or steel posts. Safety beam and safety beam-type barrier guardrail shall consist of rigid beam elements bolted to treated timber or steel posts with offset blocks. Cable guardrail shall consist of three (3) wire cables supported by cable mounts attached to steel posts.

Removing and resetting guardrail includes removing and resetting guardrail, cable, approach sections, end sections, materials, fittings, posts, and incidentals at locations indicated in the Contract Documents or as directed by the Engineer.

The work of removal of existing guardrail includes removing guardrail, cable, approach sections, end sections, and any beam guardrail materials, fittings, posts, or deadmen at locations indicated in the Contract Documents or as directed by the Engineer.

604.02 Material Requirements.

(A) Wood Posts and Offset Blocks.

Wood posts and offset blocks shall be southern pine, douglas fir, western red cedar, or northern white cedar without gains, crooks, or sweeps and shall conforming to ASTM D25, Standard Specification for Round Timber Piles, and ANSI 05.1, Wood Poles, Specifications and Dimensions. Treat posts and offset blocks using the Rueping Process with a minimum of ten (10) pounds of five (5) percent pentachlorophenol solution per cubic foot of timber in accordance with AASHTO M133, Preservatives and Pressure Treatment Process for Timber. Roof, gain, and bore posts and offset blocks before full-length preservative treatment. Locate markings ten (10) feet above the butt of the pole. Cut gains on the concave side or side having the greatest curvature in poles having a reverse or double sweep. Gained surfaces shall be in parallel planes.

Store posts and offset blocks by stacking on decay-resisting skids at least one (1) foot above the ground. Arrange skids to avoid distortion of the posts. Stack posts and offset blocks to permit free circulation of air. Remove any decaying wood from beneath stored posts and offset blocks immediately.

(B) Steel Guardrail Posts.

Fabricate steel guardrail posts, offset blocks, plates, and angles to the size, weight, and dimensions indicated in the Contract Documents or as directed by the Engineer using steel conforming to the requirements of ASTM A36, Standard Specification for Structural Steel. All welding shall be in accordance with AWS D2.0, Specifications for Welded Highway and Railway Bridges. Galvanize all steel components in accordance with ASTM A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

Bolts used with galvanized steel shall conform to ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength. Bolts used with non-galvanized components shall conform to ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength, or Type 3 bolts as defined by ASTM A325, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.

(C) Guardrail Elements, Terminal Sections, Approach Sections, and Fittings.

Galvanized steel and aluminum beam guardrail elements, terminal sections, approach sections, and fittings shall comply with the shape and dimension indicated in the Contract Documents and shall be interchangeable with similar parts regardless of source or manufacturer. The edges of the beam elements shall be smooth after fabrication. All beam elements excluding beam elements shop-curved to fit radii curves shall be straight and of uniform section. Do not use warped or deformed elements without obtaining written permission from the Engineer. Replace warped or deformed beam elements at no additional cost to the City. Galvanize all steel beam elements, terminal sections, approach sections, offset blocks, rods, plates, turnbuckles, clevises, forgings, and fittings. Guardrail element fittings shall conform to the requirements of AASHTO M180, Corrugated Sheet Steel Beams for Highway Guardrail.

Steel beam elements and terminal sections shall conform to the requirements for Type I, Class A as defined by AASHTO M180, Corrugated Sheet Steel Beams for Highway Guardrail. Fabricate aluminum beam elements and terminal sections using alclad 2024, temper T3 aluminum alloy in accordance with ASTM B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate. Shape aluminum elements in a beam twelve and one-fourth (12¼) inches wide and three (3) inches deep with a nominal thickness of one hundred fifty-six thousandth (0.156) inch using the manufacturing tolerances indicated for steel beam elements as defined by AASHTO M180, Corrugated Sheet Steel Beams for Highway Guardrail.

Galvanized plates for approach sections and anchor rods and plates shall conform to the requirements of ASTM A36, Standard

Specification for Structural Steel. Use seven-eighths (7/8) inch galvanized bolts conforming to the requirements of ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

Turnbuckles and clevises shall be steel forgings conforming to the requirements for Class C forgings as defined by ASTM A235, Standard Specification for Carbon Steel Forgings for General Industrial Use. Anneal the forgings before machining. Fabricate special end shoes using ten (10) gage steel.

(D) Guardrail Cable, Joints, Splices, and Fittings.
Guardrail cable shall be Type I, Class A as defined by ASTM A741, Standard Specification for Zinc-Coated Steel Wire Rope and Fittings for Highway Guardrail.

(E) Miscellaneous Cable Hardware.
Miscellaneous items and materials shall be of the type, size, and dimension indicated in the Contract Documents. All metal parts shall be galvanized. Anchor angles, anchor cable, turnbuckles, hooked bolts, compensating devices, fittings, and special hardware shall conform to the requirements of the Contract Documents or the Engineer. Design and fabricate cable fittings, including hook bolts, to develop the full strength of a single cable or the multiple cable assembly, as applicable.

(F) Portland Cement for PCC and Flowable Fill.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3. Do not use blended hydraulic cements without prior approval of the Engineer. Blended hydraulic cements shall conform to the requirements of ASTM C595, Standard Specification for Blended Hydraulic Cements.

(G) Fly Ash for Flowable Fill.
Fly ash shall conform to the requirements of Class C Fly Ash as defined by ASTM C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.

(H) Water for PCC and Flowable Fill.
All water used in the PCC mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(I) Aggregate for PCC and Flowable Fill.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-

five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(J) Admixtures for PCC and Flowable Fill.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC. Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(K) PCC Mix Proportioning and Required Properties.
Proportion PCC mixtures to meet the requirements of Table 604.01. PCC mixtures shall not contain any fly ash.

Table 604.01
PCC Properties

Mix Type	L6
Portland Cement Content, lbs. per cubic yard	564 min.
Coarse Aggregate, % of Total Aggregate	30±3
Fine Aggregate, % of Total Aggregate	70±3
Maximum Water Cement Ratio	0.45
Minimum 28-Day Compressive Strength, psi	3500
Entrained Air Content, %	6.5±1.0
Slump, inches	4-inch Max.
PCC Temperature during placement, °F	70±20

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(L) Flowable Fill Mix Proportioning and Required Properties.
Prepare and submit a flowable fill mix design that identifies the component materials, the proportion of such materials, the twenty-eight (28) day compressive strength, and the air content. Flowable fill shall have a twenty-eight (28) day compressive strength of 75±50 psi and an air content of 10±3%. Proportion the materials to produce a mixture with a consistency that flows under a very low head. Determine compressive strength in accordance with ASTM D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders. Determine air content in accordance with ASTM D6023, Standard Test Method for Unit Weight, Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM).

(M) Curing Materials for PCC.
Curing materials shall be membrane-forming compounds or polyethylene film. Liquid, membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

(N) Sealing Compound.
Aluminum-filled, resilient sealing compound shall be Minnesota Mining and Manufacturing Company (3M) Sealant Number 1168 or approved equal.

604.03 Construction Requirements.

Use wood or steel posts as indicated in the Contract Documents or as directed by the Engineer. Use the same post-type, offset block material, and guardrail shape and material throughout the project unless otherwise indicated in the Contract Documents or as directed by the Engineer. Submit shop drawings detailing the guardrail, beam punchings, fittings, and assemblies for guardrail to the Engineer before commencing guardrail construction. Furnish new posts, offset blocks, hardware, and other items required to reset existing guardrail. Do not commence guardrail removal or installation until completing grading work adjacent to the location of the guardrail.

Install posts plumb and firm to the depth and spacing indicated in the Contract Documents or as directed by the Engineer. Install posts by driving or using pre-bored holes and backfilling. Pre-bored holes for wood posts shall have a minimum diameter of eight (8) inches greater than the largest

horizontal dimension of the post. Pre-bored holes for steel posts shall have a minimum diameter of ten (10) inches. Replace any posts damaged during installation at no additional cost to the City. Do not drive posts if the driving operation, in the opinion of the Engineer, damages adjacent pavement or structures. Protect the post top from deformation during the driving process.

Backfill the hole around the post using flowable fill or PCC up to a point eight (8) inches below the adjacent surface. Backfill the upper eight (8) inches using material similar to the adjacent material and acceptable to the Engineer.

Install the offset blocks and guardrail along the lines and grades indicated in the Contract Documents or as directed by the Engineer. Weld or bolt steel offset blocks to steel posts. Bolt all other offset blocks to the posts. Install bearing plates or washers between the wood post and any nuts and heads of bolts.

Splice beam elements at posts at a maximum spacing of twenty-five (25) feet. Accomplish splicing using slotted holes in the beam element that allow linear expansion and contraction. Where installing splices along a curve, form the beam elements to allow the plates at the splice to contact the beam elements throughout the length of the splice. Install a terminal end section at each end of the beam guardrail unless otherwise indicated in the Contract Documents or as directed by the Engineer. Use flat round headed bolts or bolts with heads of similar detail having no appreciable projection to form all connections and splices.

Install bridge approach sections and breakaway terminal sections at the locations indicated in the Contract Documents or as directed by the Engineer. Mount bridge approach sections directly to the bridge using existing bolts, special curb mountings, or flush mountings as indicated in the Contract Documents or as directed by the Engineer.

Remove and store existing guardrail designated for removal and resetting in a manner acceptable to the Engineer that allows for future resetting. Accomplish the removal without losing or damaging the beam elements, posts, offset blocks, or hardware. Replace any guardrail component damaged or lost during the removal, storing, or resetting process at no additional cost to the City. Reset the guardrail in accordance with the procedures outlined above at the locations indicated in the Contract Documents or as directed by the Engineer.

Repair wood and steel materials as directed by the Engineer. Repair minor damage to wood surfaces by applying three (3) coats of the same type of preservative with which the material was originally treated. Allow each application to dry before applying the successive coats. Repair damage to steel galvanizing using a zinc powder and flux or a zinc-rich primer

acceptable to the Engineer and applied in accordance with the manufacturer's instructions.

Do not stress attachments to new concrete or to anchor bolts set in epoxy resin until the new concrete or epoxy resin cured a minimum of three (3) calendar days. The Engineer reserves the right to lengthen the minimum curing period.

604.04 Measurement and Payment.

The Engineer shall measure cable guardrail for payment as a single unit defined as the number of linear feet of cable guardrail supplied, constructed, and accepted. The Engineer shall conduct measurements from center to center of end posts and shall not include the length of any section of cable elements projecting beyond the end posts. Such projection is subsidiary to items for which the Contract provides direct payment. Special guardrail posts, brackets, blocks, or fittings furnished and installed in conjunction with cable guardrail are subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure beam guardrail for payment as a single unit defined as the number of linear feet of beam guardrail supplied, constructed, and accepted. The Engineer shall conduct measurements from center to center of end posts and shall not include the length of the section of beam element projecting beyond these points. Such projection is subsidiary to items for which the Contract provides direct payment. Special guardrail posts, brackets, blocks, or fittings furnished and installed in conjunction with beam or safety beam guardrail installations are subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure safety beam guardrail for payment as a single unit defined as the number of linear feet of safety beam guardrail supplied, constructed, and accepted. The Engineer shall conduct measurements from center to center of end posts and shall not include the length of the section of beam element projecting beyond these points. Such projection is subsidiary to items for which the Contract provides direct payment. Special guardrail posts, brackets, blocks, or fittings furnished and installed in conjunction with beam or safety beam guardrail installations are subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure terminal sections for payment as a single unit defined as the number of terminal sections supplied, constructed, and accepted.

The Engineer shall measure removing and resetting guardrail for payment as a single unit defined as the number of linear feet of guardrail reset and accepted. The Engineer shall conduct measurements from center to center of end posts and shall not include the distance of the section of beam element projecting beyond these points. Such projection is subsidiary to

items for which the Contract provides direct payment. Any new posts, offset blocks, hardware, and incidentals required to reset the guardrail are subsidiary to items for which the Contract provides direct payment.

Unless otherwise indicated in the Contract Documents, all costs associated with backfilling of the posts; supply and installation of necessary mounting hardware; and surface repair of wood and steel materials are subsidiary to items for which the Contract provides direct payment

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for all materials, fabrication, shop work, transportation and erection of beam rail, posts, blocks, anchors, end sections, and fittings; for post removal, excavation, backfilling, storing, preparation, erection, and galvanizing; and for all labor, materials, equipment, tools and incidentals necessary to complete the work.

Description	**Unit**
Cable Guard Rail	Linear Foot
___ Beam Guard Rail	Linear Foot
Guardrail Terminal Sections	Each
Remove and Reset Guardrail	Linear Foot

605 – SEGMENTAL RETAINING WALLS

605.01 Description.

This work includes designing, supplying, and constructing a segmental retaining wall (SRW) along the lines and grades indicated in the Contract Documents or as directed by the Engineer. Do not construct segmental retaining walls within the Right-of-Way or a City of Omaha Easement without obtaining written permission from the Engineer

605.02 Material Requirements.

(A) Segmental Retaining Wall Unit.
SRW Units shall meet the requirements of NCMA TEK 2-4, Specification for Segmental Retaining Wall Units; ASTM C1372, Standard Specification for Segmental Retaining Wall Units; and Table 605.01.

Table 605.01
SRW Units Requirements

Property	Requirement
Minimum 28-Day Compressive Strength, psi	3000
Maximum Absorption, pcf	10
Freeze/Thaw Loss, %	2.5 ± 1.5
Maximum Width Deviation, inch	± $^{1}/_{8}$
Maximum Depth Deviation, inch	± $^{1}/_{8}$
Maximum Height Deviation, inch	± $^{1}/_{16}$

(B) Geosynthetic Reinforcement.
Geosynthetic reinforcement shall consist of geotextile grid or geotextile fabric manufactured for soil reinforcement applications and meeting the requirements specified by the wall shop drawing.

(C) Drainage Collection Pipe.
Drainage collection pipe shall be PVC or corrugated HDPE pipe that is perforated or slotted. Drainage collection pipe shall meet the requirements of ASTM D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings; or AASHTO M252, Corrugated Polyethylene Drainage Pipe.

(D) Drainable Fill Material.
Drainable fill material shall be clean, free-draining aggregate materials comprised of granular fill or crushed stone. The material gradation shall conform to the requirements of Table 605.02.

Table 605.02
Drainage Aggregate Gradation

Sieve Size	Percent Passing
1”	90-100
¾”	75-100
#4	0-30
#40	0-15
#200	0-5

(E) Reinforced Backfill.
Reinforced backfill material shall be inorganic soils classified as GP, GW, SW, SP, or SM in accordance with ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soils Classification System). The reinforced backfill shall have a pH value between three (3) and nine (9). The material gradation shall conform to the requirements of Table 605.03.

Table 605.03
Reinforced Backfill Gradation

Sieve Size	Percent Passing
1”	90-100
#4	20-100
#40	0-60
#200	0-35

(F) Geotextile Filter.
Geotextile filter shall meet the requirements specified in the SRW design.

(G) Cap Adhesive.
Cap adhesive shall meet the requirements of the SRW unit manufacturer.

605.03 Construction Requirements.

(A) Engineering Design and Support.
A Professional Civil or Structural Engineer licensed in the State of Nebraska shall design the SRW in accordance with the recommendations of the current edition of the NCMA Design Manual for Segmental Retaining Walls. The SRW shall have a minimum design life of seventy-five (75) years. The SRW design shall be specific to the project application, manufacturer, and type of system proposed. Submit all design plans and calculations to the Engineer for approval.

The SRW system supplier shall provide a qualified and experienced representative acceptable to the Engineer to assist the Contractor regarding proper wall installation during construction.

(B) Grading.

Excavate to the lines and grades indicated in the Contract Documents or as directed by the Engineer. Do not over-excavate unless otherwise directed by the Engineer. Design and provide excavation support as needed at no additional cost to the City. The Engineer shall examine the foundation soils for compliance with the bearing strength requirements established during the design. Rework or remove and replace all unacceptable soils as directed by the Engineer.

(C) Leveling Pad Preparation.

The leveling pad shall consist of a minimum of six (6) inches of compacted drainage aggregate placed and compacted to the grades shown in the SRW design plans. Compact granular material to a minimum of sixty (60) percent of relative density as determined by ASTM D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density. Compact crushed stone material to ninety-five (95) percent of the maximum density as determined by ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.

(D) SRW and Geosynthetic Reinforcement Placement.

Do not commence SRW construction until receiving written authorization from the Engineer. Install all SRW and geosynthetic reinforcement in accordance with the manufacturer's recommendations at the proper elevation and orientation as directed by the Contract Documents and the SRW design. In case of conflicting requirements, the approved SRW design shall govern.

Repair or discard damaged units in accordance with the manufacturer's recommendation at no additional cost to the City. The Engineer shall approve of any repair techniques before using a repaired SRW unit. Fabricate irregularly shaped SRW units as necessary in accordance with the manufacturer's recommendation.

Do not overlap the geosynthetic reinforcement in the design strength direction. The design strength direction is the direction perpendicular to and away from the wall face. Geosynthetic reinforcement placed in this direction shall consist of one (1) continuous section of material. Place adjacent sections in a manner to meet all necessary overlap and horizontal coverage requirements. Install all geosynthetic reinforcement under nominal tension. Maintain such tension until constructing a minimum of six (6) inches of cover.

The allowable tolerance relative to the wall design verticality or batter is a maximum of one (1) inch in ten (10) feet and three (3) inches maximum for the SRW.

(E) Reinforced Backfill Placement.

Construct the reinforced backfill in lifts less than or equal to six (6) inches of compacted material. Place, spread, and compact the material in a manner that does not wrinkle or displace the geosynthetic reinforcement or SRW units. The Contractor may operate rubber-tired construction equipment directly on the geosynthetic reinforcement at speeds less than ten (10) miles per hour without unnecessary sudden braking or sharp turning. Do not use tracked construction equipment without a minimum of six (6) inches of backfill cover. Remove and replace or repair any damaged or displaced geosynthetic reinforcement at no additional cost to the City.

Construct the reinforced backfill to meet the requirements of Table 605.04. The maximum dry density and optimum moisture shall be determined by ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. The relative density shall be determined by ASTM D4253, Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

Table 605.04
Reinforced Backfill Requirements

Distance from Wall Face	Cohesive Materials		Non-Cohesive Materials
	Minimum Compaction	Moisture Range	Minimum Compaction
0 to 3 Feet	92% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%	60% of Relative Density
> 3 Feet – Not Under Pavement **or** ≥ 1 foot below finished grade	95% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%	65% of Relative Density
> 3 Feet – Under Pavement **and** ≤ 1 Foot below finished grade	90% of Maximum Dry Density (**Modified** Effort)	Optimum Moisture Content –3%, +4%	65% of Relative Density

Scarify the upper three (3) inches of material before seeding or sodding.

(F) Drainage Collection Pipe and Fill Placement.

Place the drainage collection pipe and fill as directed by the SRW design. Install drainage collection pipes to maintain gravity flow outside the reinforced soil zone. Drainage collection pipes shall empty at a location as directed by the Contract Documents.

(G) Cap Block/Top SRW Unit Placement.

Place and bond the cap block and/or top SRW unit block in accordance with the manufacturer's recommendation.

605.04 Measurement and Payment.

The Engineer shall measure segmental retaining wall as a single unit defined as the number of square feet of wall designed, supplied, constructed, and accepted. The Engineer shall conduct measurements along the exposed face of the wall after completion of all backfilling activities. The Engineer shall measure from the top of the retaining wall to the top of the leveling pad or footing along the face of the wall and from end to end.

Unless otherwise indicated in the Contract Documents, all costs associated with fabrication of irregularly shaped SRW units; providing a qualified and experienced representative from the SRW system supplier; excavation and/or over-excavation for installation of the structure; protection of an excavation; de-watering; supplying additional material for completion of backfilling operations; manipulation of existing materials; intermixing of existing materials with borrow materials, replacing existing materials with borrow materials; removal of fencing or trees; and/or replacement of fencing removed to facilitate construction are subsidiary to items for which the Contract provides direct payment. Payment will be made under the following unless otherwise indicated in the Contract Documents. This contract price shall be full compensation for all excavation, embankment, benching, granular backfill, geogrid, and pipe; and for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work including the installation of all necessary reinforcement.

Description	Unit
Construct Segmental Retaining Wall	Square Foot

THIS PAGE INTENTIONALLY LEFT BLANK

606 – REINFORCED PCC RETAINING WALLS

606.01 Description.

This work includes constructing reinforced PCC retaining walls along the lines and grades indicated in the Contract Documents or as directed by the Engineer.

606.02 Material Requirements.

(A) Portland Cement for PCC.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3. Do not use blended hydraulic cements without prior approval of the Engineer. Blended hydraulic cements shall conform to the requirements of ASTM C595, Standard Specification for Blended Hydraulic Cements.

(B) Water for PCC.
All water used in the PCC mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(C) Aggregate for PCC.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(D) Admixtures for PCC.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty

(30) revolutions before commencing placement of the PCC. Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(E) Coloring Agent for PCC.
Coloring agent shall comply with the requirements of ASTM C979, Pigments for Integrally Colored Concrete. Add coloring agent in accordance with the manufacturer's recommendations. The maximum allowable dosage for a coloring agent is ten (10) percent of the total weight of cementitious materials.

(F) PCC Stain for PCC.
PCC stain shall be a waterborne, acrylic-based stain designed for the intended use and acceptable to the Engineer.

(G) PCC Mix Proportioning.
Proportion PCC mixtures to meet the requirements of Table 606.01.

Table 606.01
PCC Properties

Mix Type	SG65	L6
Portland Cement Content, lbs. per cu. yd.	611 min.	564 min.
Coarse Aggregate, % of Total Aggregate	0	30±3
Fine Aggregate, % of Total Aggregate	100	70±3
Maximum Water Cement Ratio	0.45	0.45
Minimum 28-Day Compressive Strength, psi	3500	3500
Air Content, %	6.5±1.0	6.5±1.0
Slump, inches	2.5±1.5	2.5±1.5
PCC Temperature during placement, °F	70±20	70±20

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(H) Pre-molded Joint Filler.
Pre-molded joint filler for expansion joints shall conform to the requirements of ASTM D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). When more than one

piece is required for a joint, securely fasten the abutting ends by stapling or other positive fastening means satisfactory to the Engineer.

(I) Reinforcement for PCC.

Welded wire fabric shall conform to the requirements of ASTM A185, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement. Steel bars shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement. Keep reinforcing metal clean and free of rust or foreign material. Protect reinforcing materials from weather until placement. Supply and store welded wire sheets and welded bar mats in flat sheets.

(J) Curing Materials for PCC.

Curing materials shall be membrane-forming compounds or polyethylene film. Liquid, membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

606.03 Construction Requirements.

(N) Excavation.

Excavate footings to the footing outline and elevation indicated in the Contract Documents or established by the Engineer. Do not round or undercut footing corners or edges. Smooth the footing bed to conform to the lines, grades, and dimensions of the footings. The Engineer reserves the right to alter the bottom elevation of the footings as necessary to satisfy changes in dimensions and/or footing elevations, or to place the footing on satisfactory soils. Additional footing excavation is incidental to the work.

Protect excavations in accordance with the requirements of 29CFR Part 1926, Safety and Health Regulations for Construction. Provide all sheathing, bracing, piling, and shoring necessary to protect the excavation and all adjacent structures. Any damage to the work or to adjacent structures resulting from failure of excavation walls will be the Contractor's responsibility. Do not excavate beyond the bottom elevation indicated in the Contract Documents of any footings, walls, floors, etc., of an adjacent structure.

Accomplish excavating in a manner that does not create collected or standing water at any place on the site during construction. The excavation shall be wide enough to allow thorough tamping of the backfill adjacent to the lower portion of the structure. The minimum width shall be two (2) feet wider than the maximum horizontal width of the structure. Over-excavate a minimum of six (6) additional inches below the lower surface of the structure when encountering a rock ledge at the proposed bottom of the structure. Replace the over-excavated material using crushed rock bedding to eliminate any part of the structure from resting on the rock ledge.

When footing excavations encounter a solid rock bottom, expose and prepare the solid rock in horizontal or properly serrated beds for receiving PCC as allowed by the Engineer. Clean and grout seams or crevices. Remove loose or disintegrated rock and thin strata. Do not disturb the excavated surface where the Contract Documents indicate that PCC shall rest on excavated surface other than rock. Perform final preparation activities immediately before placing the PCC on the footing bed.

Over-excavate below the lower surface of the structure when the Engineer determines that the soils encountered will not provide adequate support for the structure. Over-excavate to a width and depth as determined by the Engineer. Do not excavate below the depths indicated. Replace over-excavated material to the established elevation using crushed rock compacted to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)). Replace unnecessary over-excavation at no additional cost to the City.

De-water the footing excavation whenever encountering a water-bearing stratum. De-water the footing excavation by draining, pumping, bailing, or other methods approved by the Engineer to an elevation below the bottom footing elevation. Maintain the footing excavation as dry as possible or as practicable during the placing and hardening of the PCC.

(O) Equipment.

The National Ready Mixed Concrete Association shall certify that the PCC production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the PCC production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

The production facility shall provide the batch information for each load of PCC delivered to the site. The batch information shall accompany each load delivered to the site. At a minimum, the batch information shall include the component materials, the actual batch weights and target batch weights of component materials, free moisture content of aggregates, water cement ratio of batch, and amount of additional water added at production facility after batching.

Vibrators shall be internal, tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

(P) Reinforcing Steel Placement.

Place steel reinforcement as directed by the Contract Documents. Place the reinforcement within one-fourth (¼) inch of the elevation required in the Contract Documents. Position the reinforcement before placing the PCC. Use metal supports acceptable to the Engineer to maintain the position of the reinforcement. Do not place any load on positioned reinforcement that causes the reinforcement to move out of position. Maintain the position of the reinforcement before, during, and after PCC placement. Overlap adjacent sheets of wire fabric a minimum of twelve (12) inches. Keep sheets straight during and after installation. Tie lapped sheets using steel wire or other material acceptable to the Engineer. Tie longitudinal laps at a spacing of twenty-four (24) inches or less.

(Q) Forms for PCC.

Use forms comprised of wood or metal. Wood forms shall be rigid and finished on the PCC side of the form. The rigidity of the forms shall be as needed to resist deformation under the PCC load. Anchor forms as necessary to maintain shape. Support forms to prevent movement of the forms during curing of the PCC. The Engineer reserves the right to reject structures damaged by movement of the forms. Clean and oil forms before PCC placement. Bed and join forms neatly and tightly to line and grade in a manner that resists movement. Do not place forms on pedestals to maintain proper grade. Remove and reset forms that vary more than one-fourth (¼) inch from line or grade.

(R) PCC Placement.

Provide sufficient lighting for placement and finishing operations as instructed by the Engineer. Do not place PCC at night or in low-light conditions without the Engineer's permission. Locate weep holes as indicated in the Contract Documents. Construct a PCC header sized and located as indicated in the Contract Documents. For colored PCC applications and imprinted applications, prepare a complete test sample of the PCC for approval by the Engineer before commencing construction of the colored or imprinted PCC.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of construction joints to achieve a saturated surface-dry condition immediately before PCC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

For evaporation rates greater than two-tenths pounds per square feet per hour (0.2 lbs/ft^2/hr), take precautions against shrinkage cracking acceptable to the Engineer. Determine the evaporation rate in accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[7]

[7] Figure reprinted with written permission from ACI International.

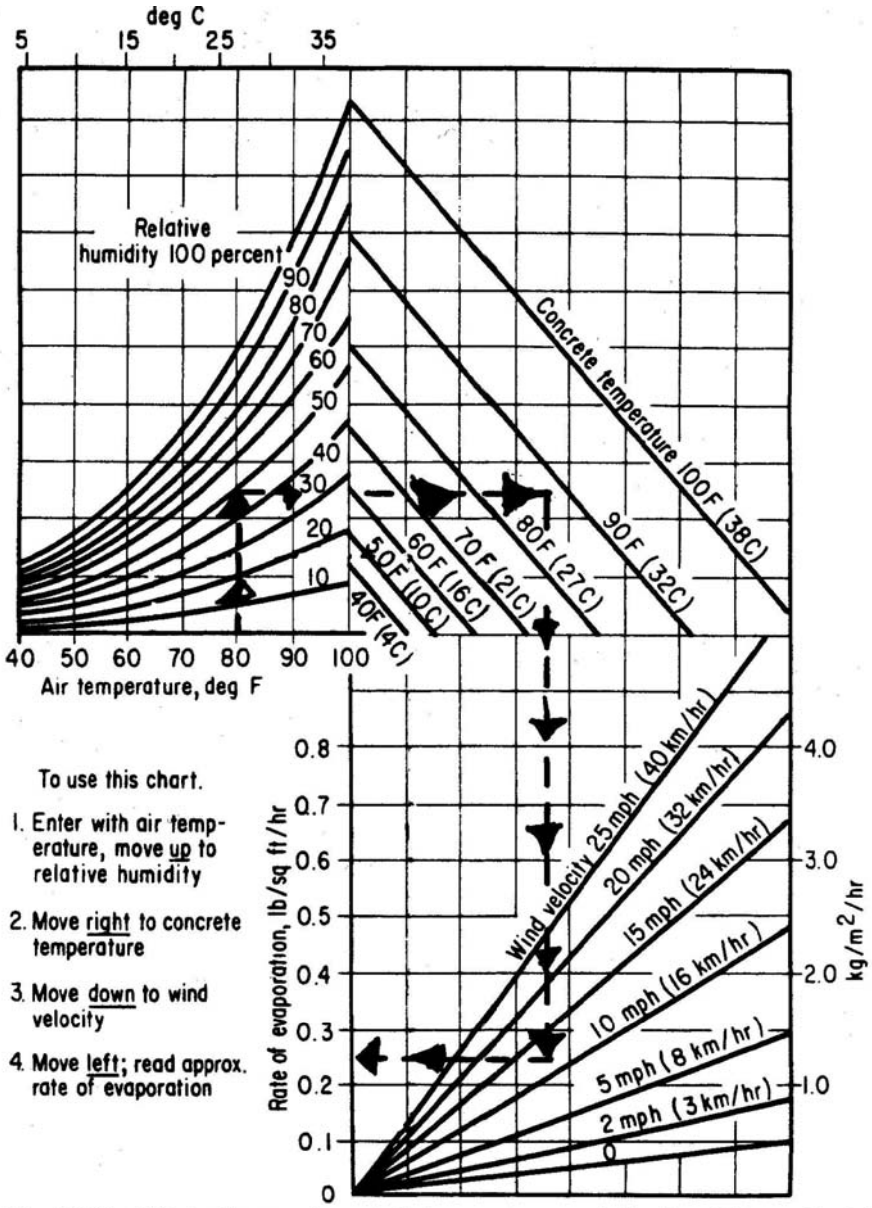

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

During cold weather periods, do not commence PCC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature

falls below forty (40) degrees Fahrenheit. Do not place PCC below the minimum allowable temperature without prior authorization by the Engineer. PCC placement below the minimum temperatures shall include all necessary measures to maintain the temperature of the PCC at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days. Do not place PCC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place the PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the PCC in a manner that minimizes segregation.

Use chutes and/or pipes to convey PCC from the mixer or transport vehicle to the forms. Use chutes and pipes comprised of metal or metal lined with plastic, rubber, or other non-deteriorating material acceptable to the Engineer. Equip steep chutes with baffle boards or use short sections that reverse the direction of movement. Extend chutes or pipes inside the forms or through holes left in the form as necessary. Do not allow the PCC to drop a distance greater than five (5) vertical feet. Remove any hardened PCC or other debris before using chutes and pipes. Adjust the chute or pipe discharge ends to facilitate proper PCC placement.

Place the PCC in continuous horizontal layers having a maximum thickness of twenty (20) inches unless otherwise indicated in the Contract Documents or approved by the Engineer. Deposit PCC in each part of the forms as near to the final position as possible.

Consolidate the PCC under and around the reinforcement bars without displacing them. Stop monolithic placements at a vertical bulkhead. Avoid spattering forms or reinforcement bars with PCC when such spattering may harden before incorporation into the mass. Regulate PCC placement to prevent the fluid PCC pressure from exceeding the values used during the design of the forms.

Place PCC using pumping equipment as necessary. Use equipment that has sufficient capacity and is acceptable to the Engineer. Do not use components comprised of aluminum or aluminum alloy to convey the PCC. Pumping equipment shall introduce, transport, and discharge the PCC continuously without segregating or introducing air pockets into the material. Do not place the PCC materials used to prime the pumping equipment. Waste such material until the PCC discharged is uniform with the other material in the pumping system as determined by the Engineer. Perform all testing on PCC material after discharging the material from the pumping equipment.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

After placing and before striking off, consolidate PCC using internal vibration provided by a tube vibrators. Insert and immediately remove manual vibrators at regular intervals less than three (3) feet apart. Do not drag manual vibrators through the PCC.

Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC.

(S) Finishing, Curing, and Protecting the PCC.

Strike off and finish the PCC to the elevation specified in the Contract Documents using equipment and techniques acceptable to the Engineer. Before commencing strike-off or finishing, remove any material or material build-up from the top of the forms. The maximum allowable deviation from plane is one-eighth ($^1/_8$) inch in any three (3) foot span. The maximum allowable deviation from the specified elevation is minus zero (-0) plus one-fourth (+¼) inch.

Minimize screeding, floating, and troweling operations to avoid overworking or over-manipulation of the PCC. Remove any free water present on the PCC surface between finishing operations in a manner acceptable to the Engineer. Do not use neat cement or sand-cement mixtures to remove free water. Do not use finishing tools on PCC having free water present on the surface.

Apply an evaporation retardant acceptable to the Engineer to the surface as necessary. Minimize the amount of water added to the PCC surface to aid in finishing. Add an evaporation retardant or water by misting. Immediately remove excessive amounts of water as determined by the Engineer in a manner acceptable to the Engineer. Do not conduct finishing operations if free water is present on the PCC surface.

Within one (1) hour of PCC placement, protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer. For colored PCC applications, thin the liquid curing compound in accordance with the manufacturer's instructions and apply at the application rate recommended by the manufacturer.

Apply PCC stains in accordance with the manufacturer's recommendations.

(T) Form Removal.

Remove forms and any blocks or bracing as soon as practicable and safe to permit the required surface finishing. Remove forms in a manner that avoids damaging the PCC. Do not partially remove any forms without approval by the Engineer. Do not remove forms when the ambient temperature is less than forty (40) degrees Fahrenheit without protecting the exposed PCC surface in a manner acceptable to the Engineer.

Immediately following the removal of forms, remove all fins and irregular projections from all exposed surfaces. Repair any cavities, holes, honeycomb spots, broken corners or edges, and other defects by cleaning, saturating with water, and filling with a non-shrinking grout or mortar. Finish the grout or mortar to obtain a sound, smooth, and uniform surface. Remove the protruding ends of plastic ties flush with the PCC surface.

Apply a damp-proof coating consisting of a primer and damp-proofing material to the non-exposed surfaces of the PCC retaining wall as directed by the Engineer. Limit all damp-proofing materials to the

treated areas. Do not disfigure untreated portions of the stairs with damp-proofing materials. Uniformly apply one (1) coat of primer and two (2) coats of damp-proofing material in accordance with the manufacturer's instructions. Perform damp-proofing in dry weather when the ambient temperature is forty (40) degrees Fahrenheit or above. Allow each coating to dry before applying the next coating in accordance with the manufacturer's recommendations. Allow the damp-proofing to cure in accordance with the manufacturer's recommendations before commencing backfilling operations.

(U) Construction Joints.

Construct construction joints to the dimensions indicated in the Contract Documents. Clean the construction joint immediately before sealing operations. Place joint sealant in the sawed construction joint to one-fourth (¼) inch below the PCC surface.

(V) Defective or Substandard PCC.

Remove and replace in accordance with the Contract Documents any portion(s) of the PCC placement that contains random cracking, plastic shrinkage cracking, scaling, spalls, honeycombs, high spots, depressions, or other defects or substandard conditions as determined by the Engineer. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

The maximum allowable deviation from plane is one-half (½) inch in any ten (10) foot span. The maximum allowable deviation from the specified elevation is minus zero (-0), plus one-half (+½) inch. The maximum allowable deviation for horizontal alignment is one (1) inch. The maximum allowable deviation for horizontal alignment at tie-in locations is one-half (½) inch.

(W) Backfill.

Construct backfill in lifts less than or equal to six (6) inches of compacted material. Place, spread, and compact the material in a manner that does not damage the wall.

Construct backfill to meet the requirements of Table 606.02. The maximum dry density and optimum moisture shall be determined by ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. The relative density shall be determined by ASTM D4253, Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

Table 606.02
Reinforced Backfill Requirements

Distance from Wall Face	Cohesive Materials		Non-Cohesive Materials
	Minimum Compaction	**Moisture Range**	**Minimum Compaction**
0 to 3 Feet	92% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%	60% of Relative Density
> 3 Feet – Not Under Pavement **or** ≥ 1 foot below finished grade	95% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%	65% of Relative Density
> 3 Feet – Under Pavement **and** ≤ 1 Foot below finished grade	90% of Maximum Dry Density (**Modified** Effort)	Optimum Moisture Content –3%, +4%	65% of Relative Density

Scarify the upper three (3) inches of material before seeding or sodding.

606.04 Measurement and Payment.

The Engineer shall measure reinforced PCC retaining walls for payment as a single unit defined as the number of cubic yards of reinforced PCC retaining wall constructed and accepted. The Engineer shall determine the volume based upon measurements of the completed reinforced PCC wall.

Unless otherwise indicated in the Contract Documents, all costs associated with construction of weepholes; texturing; coloring; special finishing; excavation and/or over-excavation for installation of the structure; protection of an excavation; de-watering; supplying additional material for completion of backfilling operations; manipulation of existing materials; intermixing of existing materials with borrow materials, replacing existing materials with borrow materials; removal of fencing or trees; and/or replacement of fencing removed to facilitate construction are subsidiary to items for which the Contract provides direct payment. Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for the cost for all forming, PCC placement, reinforcement, and dowel bars; for all grouting; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Construct Reinforced PCC Retaining Wall	Cubic Yard

607 – NOISE WALLS

607.01 Description.

This work includes supplying and constructing noise walls in accordance with the lines, grades, and details indicated in the Contract Document or as directed by the Engineer.

607.02 Material Requirements.

(A) General.
All grout, mortar, and PCC shall meet the coloring requirement indicated in the Contract Documents or identified by the Engineer. Provide colored samples of the proposed grout, mortar, and PCC to the Engineer upon request at no additional cost to the City.

(B) Portland Cement for PCC.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3. Do not use blended hydraulic cements without prior approval of the Engineer. Blended hydraulic cements shall conform to the requirements of ASTM C595, Standard Specification for Blended Hydraulic Cements.

(C) Water for PCC.
All water used in the PCC mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(D) Aggregate for PCC.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(E) Admixtures for PCC.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of

calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC. Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(F) Coloring Agents for PCC.

Coloring agents shall comply with the requirements of ASTM C979, Pigments for Integrally Colored Concrete. Add coloring agents in accordance with the manufacturer's recommendations. The maximum allowable dosage for a coloring agent is ten (10) percent of the total weight of cementitious materials.

(G) PCC Stain for PCC.

PCC stain shall be a waterborne, acrylic-based stain designed for the intended use and acceptable to the Engineer.

(H) PCC Mix Proportioning.

Proportion PCC mixtures to meet the requirements of Table 607.01.

Table 607.01
PCC Properties

Mix Type	L6
Portland Cement Content, lbs. per cu. yd.	564 min.
Coarse Aggregate, % of Total Aggregate	30±3
Fine Aggregate, % of Total Aggregate	70±3
Maximum Water Cement Ratio	0.45
Minimum 28-Day Compressive Strength, psi	3500
Air Content, %	6.5±1.0
Slump, inches	2.5±1.5
PCC Temperature during placement, °F	70±20

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(I) Reinforcing Steel for PCC.

Reinforcing steel shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

(J) Pre-molded Joint Filler.

Pre-molded joint filler for expansion joints shall conform to the requirements of ASTM D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). Neatly punch holes to admit the dowels where indicated in the Contract Documents. The diameter of the holes shall not exceed one-half (½) inch greater than the bar diameter. When more than one piece is required for a joint, securely fasten the abutting ends by stapling or other positive fastening means satisfactory to the Engineer.

(K) Curing Materials for PCC.

Curing materials shall be liquid membrane-forming compounds or polyethylene film. Liquid membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

(L) Prefabricated Wall Panels.

Design prefabricated wall panels to be noise reflective and conform to the requirements of the Contract Documents. Prefabricated wall panels shall be PCC unless otherwise indicated in the Contract Documents.

(M) Prefabricated Columns.

Design prefabricated columns to integrate and support wall panels and conform to the requirements of the Contract Documents. Prefabricated columns shall be PCC unless otherwise indicated in the Contract Documents.

607.03 Construction Requirements.

(A) General.

Avoid damaging any nearby fencing or trees that do not restrict construction. Do not remove any fencing or trees unless otherwise indicated in the Contract Documents. Replace any fencing removed to

facilitate PCC noise wall construction in a manner acceptable to the Engineer.

The National Ready Mixed Concrete Association shall certify that the PCC production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the PCC production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

The production facility shall provide the batch information for each load of PCC delivered to the site. The batch information shall accompany each load delivered to the site. At a minimum, the batch information shall include the component materials, the actual batch weights and target batch weights of component materials, free moisture content of aggregates, water cement ratio of batch, and amount of additional water added at production facility after batching.

Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

All equipment, tools, and machinery used in the work shall be adequate for the intended use. Maintain all equipment, tools, and machinery used in the work in a satisfactory working condition.

(B) Excavation.

Excavate footings to the footing outline and elevation indicated in the Contract Documents or as established by the Engineer. Do not round or undercut footing corners or edges. Smooth the footing bed to conform to the lines, grades, and dimensions of the footings. The Engineer reserves the right to alter the bottom elevation of the footings as necessary to satisfy changes in dimensions and/or footing elevations or to place the footing on satisfactory soils.

When footing excavations encounter a solid rock bottom, expose and prepare the solid rock in horizontal or properly serrated beds for receiving PCC as allowed by the Engineer. Clean and grout seams or crevices. Remove loose or disintegrated rock and thin strata. Do not disturb the excavated surface where the Contract Documents indicate that PCC shall rest on excavated surface other than rock. Perform final preparation activities immediately before placing the PCC on the footing bed.

De-water the footing excavation when encountering a water-bearing stratum. De-water the footing excavation by draining, pumping, bailing, or other methods approved by the Engineer to an elevation below the bottom footing elevation. Maintain the footing excavation as dry as possible or practicable during the placing and hardening of the PCC.

Excavate footings to the width and depth designated by the Engineer when the foundation bed contains soft, unstable, saturated soils or conditions that prohibit the proper footing construction. Backfill the area with porous, granular material acceptable to the Engineer to the footing elevation indicated in the Contract Documents or established by the Engineer. Maintain any water at an elevation below the top of the porous, granular material until completion of the footing construction.

(C) Forms for PCC.

Use forms comprised of metal, wood, or other material acceptable to the Engineer. Do not use forms comprised of aluminum. Forms shall be mortar-tight, produce a uniform surface texture and appearance acceptable to the Engineer, and be sufficiently rigid to prevent distortion due to pressures of PCC, vibration, and other loads associated with construction operations. Joints shall be tight and cut smooth. Wood forms shall be finished on the PCC side of the form and maintained to prevent warping and opening of joints due to shrinkage of lumber. Align consecutive wood forms to match the joints and grain of the wood. Use the same form material for all PCC barrier curb constructed on the project unless otherwise approved by the Engineer in writing. Do not re-use forms or form materials failing to satisfy any shape, strength, rigidity, mortar tightness, or surface smoothness requirements. Do not use warped or bulged lumber.

Design the forms to permit removal of any ties or anchors contained within the forms to a minimum depth of one (1) inch beneath the surface of the PCC without injury to the PCC.

Bed and join forms neatly and tightly to line and grade in a manner that resists movement. Do not place forms on pedestals to maintain proper grade. Remove and reset forms that vary more than one-fourth (¼) inch in ten (10) feet from line or grade. Remove any dirt, sawdust, or other extraneous materials from the forms before placing the PCC. Treat form surfaces with form oil or other material acceptable to the Engineer that prevents bonding of the PCC to the form. Such material shall not adhere to or discolor the PCC surface.

(D) Placing Reinforcing Steel.

Place steel reinforcement as directed by the Contract Documents. Place the reinforcement within one-fourth (¼) inch of the elevation required in the Contract Documents. The Contractor shall position the reinforcement before placing the PCC. Use metal supports acceptable

to the Engineer to maintain the position of the reinforcement. Do not place any load on positioned reinforcement that causes the reinforcement to move out of position. Maintain the position of the reinforcement before, during, and after PCC placement.

(E) PCC Placement.

Provide sufficient lighting for placement and finishing operations as instructed by the Engineer. Do not place PCC at night or in low-light conditions without the Engineer's permission. For colored PCC applications and imprinted applications, prepare a complete test sample of the PCC for approval by the Engineer before commencing construction of the colored or imprinted PCC.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of construction joints to achieve a saturated surface-dry condition immediately before PCC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

For evaporation rates greater than two-tenths pounds per square feet per hour (0.2 lbs/ft^2/hr), take precautions against shrinkage cracking acceptable to the Engineer. Determine the evaporation rate in accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[8]

[8] Figure reprinted with written permission from ACI International.

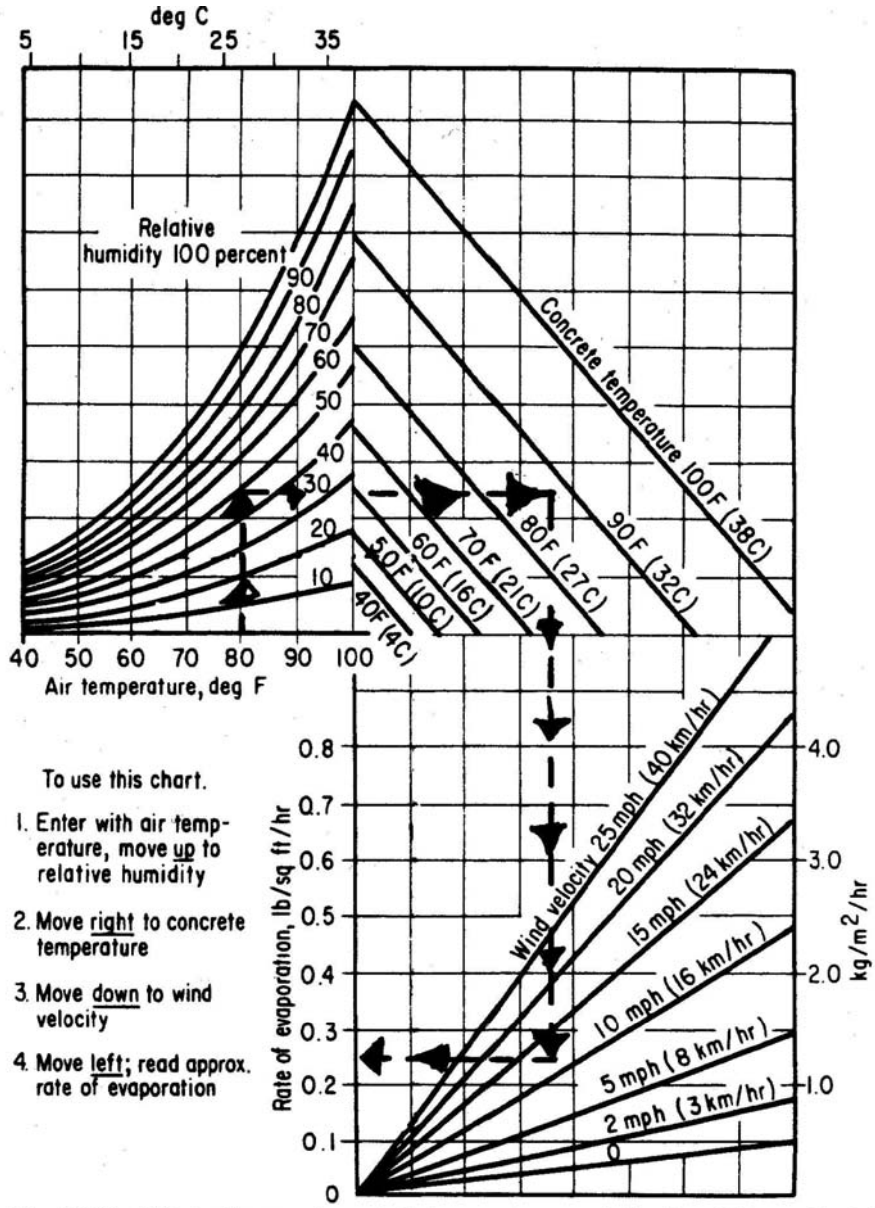

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

During cold weather periods, do not commence PCC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature

falls below forty (40) degrees Fahrenheit. Do not place PCC below the minimum allowable temperature without prior authorization by the Engineer. PCC placement below the minimum temperatures shall include all necessary measures to maintain the temperature of the PCC at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days. Do not place PCC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the PCC in a manner that minimizes segregation.

Use chutes and/or pipes to convey PCC from the mixer or transport vehicle to the forms. Use chutes and pipes comprised of metal or metal lined with plastic, rubber, or other non-deteriorating material acceptable to the Engineer. Equip steep chutes with baffle boards or use short sections that reverse the direction of movement. Extend chutes or pipes inside the forms or through holes left in the form as necessary. Do not allow the PCC to drop a distance greater than five (5) vertical feet. Remove any hardened PCC or other debris before using chutes and pipes. Adjust the chute or pipe discharge ends to facilitate proper PCC placement.

Place the PCC in continuous horizontal layers having a maximum thickness of twenty (20) inches unless otherwise indicated in the Contract Documents or approved by the Engineer. Deposit PCC in each part of the forms as near to the final position as possible.

Consolidate the PCC under and around the reinforcement bars without displacing them. Stop monolithic placements at a vertical bulkhead. Avoid spattering forms or reinforcement bars with PCC when such spattering may harden before incorporation into the mass. Regulate PCC placement to prevent the fluid PCC pressure from exceeding the values used during design of the forms.

Place PCC using pumping equipment as necessary. Use equipment that has sufficient capacity and is acceptable to the Engineer. Do not use components comprised of aluminum or aluminum alloy to convey the PCC. Pumping equipment shall introduce, transport, and discharge the PCC continuously without segregating or introducing air pockets into the material. Do not place the PCC materials used to prime the pumping equipment. Waste such material until the PCC discharged is uniform with the other material in the pumping system as determined by the Engineer. Perform all testing on PCC material after discharging the material from the pumping equipment.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

After placing and before striking off, consolidate PCC using internal vibration provided by a tube vibrator. Insert and immediately remove manual vibrators at regular intervals less than three (3) feet apart. Do not drag manual vibrators through the PCC. Use a tube vibrator for all formed placements. Place and consolidate each layer before the preceding layers has taken initial set to prevent injury to the fresh PCC and avoid surfaces of separation between layers.

Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC.

(F) Finishing, Curing, and Protecting PCC.

The Contractor shall strike off and finish the PCC to the elevation specified in the Contract Documents. Remove material build-up from the forms before strike off or finishing begins. Finish all PCC surfaces not contained within the forms in a manner acceptable to the Engineer.

Minimize screeding, floating, and troweling operations to avoid overworking or over-manipulation of the PCC. Remove any free water present on the PCC surface between finishing operations in a manner acceptable to the Engineer. Do not use neat cement or sand-cement mixtures to remove free water. Do not use finishing tools on PCC having free water present on the surface.

Apply an evaporation retardant acceptable to the Engineer to the surface as necessary. Minimize the amount of water added to the PCC surface to aid in finishing. Add water only by misting. Immediately remove excessive amounts of water as determined by the Engineer in a manner acceptable to the Engineer. Do not conduct finishing operations if free water is present on the PCC surface.

With one (1) hour of PCC placement, protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer.

Remove forms as soon practicable and safe to permit the required surface finishing. Remove any blocks or bracing with the forms. Do not use removal methods that in the opinion of the Engineer may overstress or otherwise damage the PCC. Do not partially remove any forms without approval by the Engineer. Do not remove forms when the ambient temperature is less than forty (40) degrees Fahrenheit without protecting the exposed PCC surface in a manner acceptable to the Engineer. Immediately following the removal of forms, remove all fins and irregular projections from all exposed surfaces.

Repair any cavities, holes, honeycomb spots, broken corners or edges, and other defects by cleaning, saturating with water, and filling with a non-shrinking grout or mortar. Finish the grout or mortar to obtain a sound, smooth, and uniform surface. Finish the grout to obtain a sound, smooth, and uniform surface. Remove the protruding ends of plastic ties flush with the PCC surface.

(G) Defective or Substandard PCC.

Remove and replace in accordance with the Contract Documents any portion(s) of the PCC placement that contains random cracking, plastic shrinkage cracking, scaling, spalls, honeycombs, high spots, depressions, or other defects or substandard conditions as determined by the Engineer. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

The maximum allowable deviation from plane is one-half (½) inch in any ten (10) foot span. The maximum allowable deviation from the

specified elevation is minus zero (-0), plus one-half (+½) inch. The maximum allowable deviation for horizontal alignment is one (1) inch. The maximum allowable deviation for horizontal alignment at tie-in locations is one-half (½) inch.

(H) Prefabricated Wall Panels and Prefabricated Columns Installation. Store, handle, and install precast units without cracking or damaging the units. Replace any damaged units at no additional cost to the City. Repair minor chips, spalls, and sears only with the approval of the Engineer. Seal all lift slots and dowel holes by cleaning, saturating with water, and filling with a non-shrinking grout or mortar.

607.04 Measurement and Payment.

The Engineer shall measure PCC noise walls for payment as a single unit defined as the number of square feet of PCC noise wall supplied, constructed, and accepted. The Engineer shall measure the length of noise walls from edge of column to edge of column along the face of the wall. The Engineer shall measure the height of the wall from top of wall to top of ground along the face of the wall.

The Engineer shall measure columns for payment as a single unit defined as the number of cubic yards of column constructed and accepted. The Engineer shall measure the volume of the column based on the physical dimensions of the constructed column.

Unless otherwise indicated in the Contract Documents, all costs associated with excavation and/or over-excavation for installation of the PCC noise wall; protection of an excavation; de-watering; supplying additional material for completion of backfilling operations; manipulation of existing materials; intermixing of existing materials with borrow materials, replacing existing materials with borrow materials; removal of fencing or trees; and/or repair or replacement of fencing or trees removed to facilitate construction are subsidiary to items for which the Contract provides direct payment. Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for the cost for all forming, PCC placement, and reinforcement; for transporting and placing precast units; for all excavation, back fill, grading, fence removal and replacement, and tree removal; for all grouting; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Noise Wall, ___ Color	Square Feet
Noise Wall Column, ___ Color	Cubic Yard

608 – PCC STAIRS

608.01 Description.

This work includes constructing cast-in-place PCC stairs along the lines and grades indicated in the Contract Documents or as directed by the Engineer.

608.02 Material Requirements.

(A) Portland Cement for PCC.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3. Do not use blended hydraulic cements without prior approval of the Engineer. Blended hydraulic cements shall conform to the requirements of ASTM C595, Standard Specification for Blended Hydraulic Cements.

(B) Water for PCC.
All water used in the PCC mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(C) Aggregate for PCC.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(D) Admixtures for PCC.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC. Do not use

any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(E) Coloring Agent for PCC.
Coloring agent shall comply with the requirements of ASTM C979, Pigments for Integrally Colored Concrete. Add coloring agent in accordance with the manufacturer's recommendations. The maximum allowable dosage for a coloring agent is ten (10) percent of the total weight of cementitious materials.

(F) PCC Stain for PCC.
PCC stain shall be a waterborne, acrylic-based stain designed for the intended use and acceptable to the Engineer.

(G) PCC Mix Proportioning.
Proportion PCC mixtures to meet the requirements of Table 608.01.

Table 608.01
PCC Properties

Mix Type	SG65	L6
Portland Cement Content, lbs. per cu. yd.	611 min.	564 min.
Coarse Aggregate, % of Total Aggregate	0	30±3
Fine Aggregate, % of Total Aggregate	100	70±3
Maximum Water Cement Ratio	0.45	0.45
Minimum 28-Day Compressive Strength, psi	3500	3500
Air Content, %	6.5±1.0	6.5±1.0
Slump, inches	2.5±1.5	2.5±1.5
PCC Temperature during placement, °F	70±20	70±20

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(H) Pre-molded Joint Filler.
Pre-molded joint filler for expansion joints shall conform to the requirements of ASTM D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). When more than one

piece is required for a joint, securely fasten the abutting ends by stapling or other positive fastening means satisfactory to the Engineer.

(I) Reinforcement for PCC.

Welded wire fabric shall conform to the requirements of ASTM A185, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement. Steel bars shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement. Keep reinforcing metal clean and free of rust or foreign material. Protect reinforcing materials from weather until placement. Supply and store welded wire sheets and welded bar mats in flat sheets.

(J) Curing Materials for PCC.

Curing materials shall be membrane-forming compounds or polyethylene film. Liquid, membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

608.03 Construction Requirements.

(A) Excavation.

Excavate footings to the footing outline and elevation indicated in the Contract Documents or as established by the Engineer. Do not round or undercut footing corners or edges. Smooth the footing bed to conform to the lines, grades, and dimensions of the footings. The Engineer reserves the right to alter the bottom elevation of the footings as necessary to satisfy changes in dimensions and/or footing elevations or to place the footing on satisfactory soils.

Protect excavations in accordance with the requirements of 29CFR Part 1926, Safety and Health Regulations for Construction. Provide all sheathing, bracing, piling, and shoring necessary to protect the excavation and all adjacent structures. Any damage to the work or to adjacent structures resulting from failure of excavation walls will be the Contractor's responsibility. Do not excavate beyond the bottom elevation indicated in the Contract Documents of any footings, walls, floors, etc., of an adjacent structure.

Accomplish excavating in a manner that does not create collected or standing water at any place on the site during construction. The excavation shall be wide enough to allow thorough tamping of the backfill adjacent to the lower portion of the structure. The minimum width shall be two (2) feet wider than the maximum horizontal width of the structure. Over-excavate a minimum of six (6) additional inches below the lower surface of the structure when encountering a rock ledge at the proposed bottom of the structure. Replace the over-excavated material using crushed rock bedding to eliminate any part of the structure from resting on the rock ledge.

When footing excavations encounter a solid rock bottom, expose and prepare the solid rock in horizontal or properly serrated beds for receiving PCC as allowed by the Engineer. Clean and grout seams or crevices. Remove loose or disintegrated rock and thin strata. Do not disturb the excavated surface where the Contract Documents indicate that PCC shall rest on excavated surface other than rock. Perform final preparation activities immediately before placing the PCC on the footing bed.

Over-excavate below the lower surface of the structure when the Engineer determines that the soils encountered will not provide adequate support for the structure. Over-excavate to a width and depth as determined by the Engineer. Do not excavate below the depths indicated. Replace over-excavated material to the established elevation using crushed rock compacted to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).

De-water the footing excavation whenever encountering a water-bearing stratum. De-water the footing excavation by draining, pumping, bailing, or other methods approved by the Engineer to an elevation below the bottom footing elevation. Maintain the footing excavation as dry as possible or practicable during the placing and hardening of the PCC.

(B) Equipment.

The National Ready Mixed Concrete Association shall certify that the PCC production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the PCC production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

The production facility shall provide the batch information for each load of PCC delivered to the site. The batch information shall accompany each load delivered to the site. At a minimum, the batch information shall include the component materials, the actual batch weights and target batch weights of component materials, free moisture content of aggregates, water cement ratio of batch, and amount of additional water added at production facility after batching.

Vibrators shall be internal, tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

(C) Reinforcement Placement.

Place steel reinforcement as directed by the Contract Documents. Place the reinforcement within one-fourth (¼) inch of the elevation required in the Contract Documents. Position the reinforcement before placing the PCC. Use metal supports acceptable to the Engineer to maintain the position of the reinforcement. Do not place any load on positioned reinforcement that causes the reinforcement to move out of position. Maintain the position of the reinforcement before, during, and after PCC placement. Overlap adjacent sheets of wire fabric a minimum of twelve (12) inches. Keep sheets straight during and after installation. Tie lapped sheets using steel wire or other material acceptable to the Engineer. Tie longitudinal laps at a spacing of twenty-four (24) inches or less.

(D) Forms.

Use forms for the sides and exposed faces of all stairs. Forms may be comprised of wood or metal. Wood forms shall be rigid and finished on the PCC side of the form. The rigidity of the forms shall be as needed to resist deformation under the PCC load. Anchor forms as necessary to maintain shape. Support forms to prevent movement of the forms during curing of the PCC. The Engineer reserves the right to reject structures damaged by movement of the forms. Clean and oil forms before PCC placement. Bed and join forms neatly and tightly to line and grade in a manner that resists movement. Do not place forms on pedestals to maintain proper grade. Remove and reset forms that vary more than one-fourth (¼) inch from line or grade.

(E) Pre-formed Expansion Joints.

Construct pre-formed expansion joints at the locations indicated in the Contract Documents. Place the pre-molded joint filler across the transverse length of the abutting structure and extend from one (1) inch below the abutting structure or stair surface to the bottom of the abutting structure or stair. Maintain the position of the pre-molded joint filler in a manner acceptable to the Engineer.

(F) PCC Placement.

Provide sufficient lighting for placement and finishing operations as instructed by the Engineer. Do not place PCC at night or in low-light conditions without the Engineer's permission. Construct a PCC header sized and located as indicated in the Contract Documents. For colored PCC applications and imprinted applications, prepare a complete test sample of the PCC for approval by the Engineer before commencing construction of the colored or imprinted PCC.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of construction joints to achieve a saturated surface-dry condition immediately before PCC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

For evaporation rates greater than two-tenths pounds per square feet per hour (0.2 lbs/ft^2/hr), take precautions against shrinkage cracking acceptable to the Engineer. Determine the evaporation rate in

accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[9]

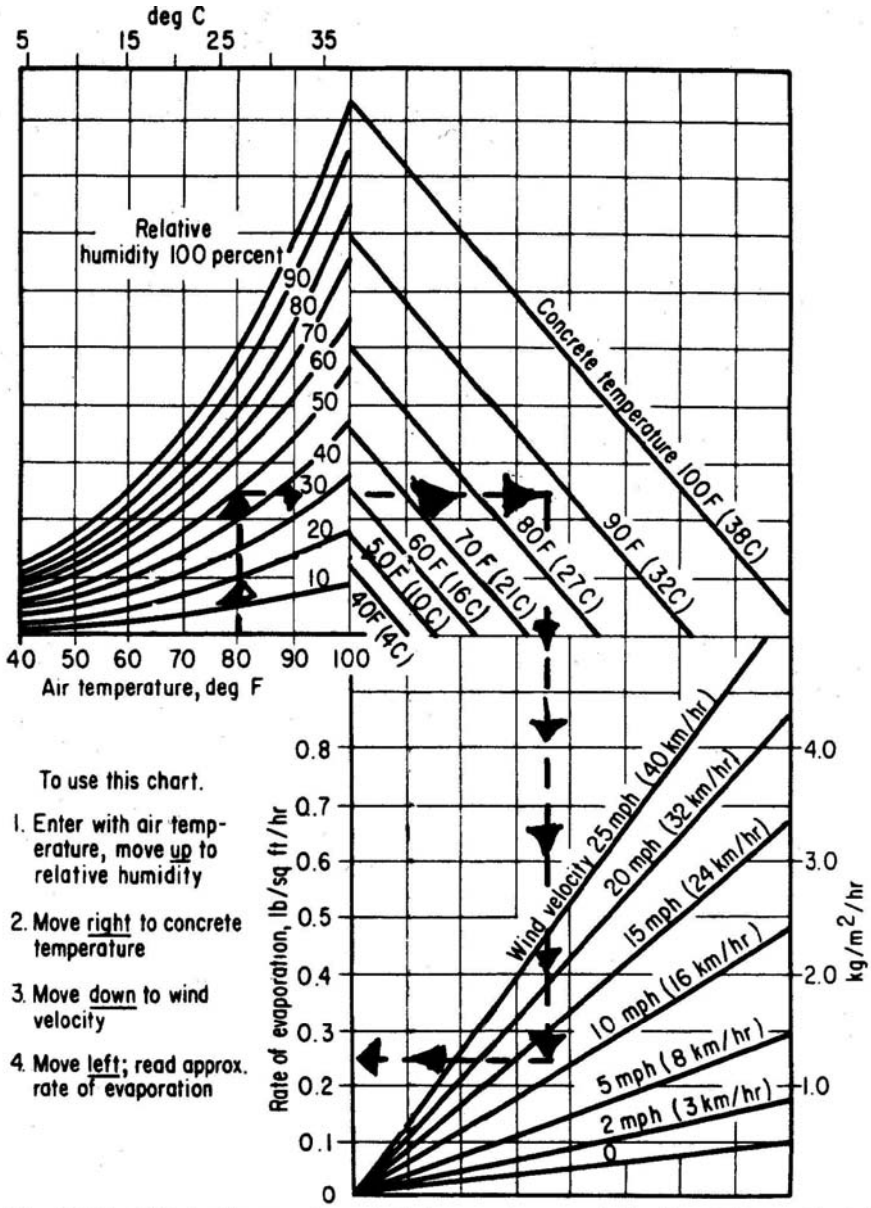

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

[9] Figure reprinted with written permission from ACI International.

During cold weather periods, do not commence PCC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature falls below forty (40) degrees Fahrenheit. Do not place PCC below the minimum allowable temperature without prior authorization by the Engineer. PCC placement below the minimum temperatures shall include all necessary measures to maintain the temperature of the PCC at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days. Do not place PCC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place the PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the PCC in a manner that minimizes segregation.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

After placing and before striking off, consolidate PCC using internal vibration provided by a tube vibrator. Insert and immediately remove manual vibrators at regular intervals less than three (3) feet apart. Do not drag manual vibrators through the PCC.

Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC.

At the completion of the placement or if the placement is interrupted by more than thirty (30) minutes, place a transverse construction joint extending the full width and depth of the placement. Locate the transverse construction joint in the placed PCC at the location of the closest joint indicated in the Contract Documents.

(G) Finishing, Curing, and Protecting the PCC.

Strike off and finish the PCC to the elevation specified in the Contract Documents using equipment and techniques acceptable to the Engineer. Before commencing strike-off or finishing, remove any material or material build-up from the top of the forms. The maximum allowable deviation from plane is one-eighth (⅛) inch in any three (3) foot span. The maximum allowable deviation from the specified elevation is minus zero (-0) plus one-fourth (+¼) inch.

Minimize screeding, floating, and troweling operations to avoid overworking or over-manipulation of the PCC. Remove any free water present on the PCC surface between finishing operations in a manner acceptable to the Engineer. Do not use neat cement or sand-cement mixtures to remove free water. Do not use finishing tools on PCC having free water present on the surface.

Apply an evaporation retardant acceptable to the Engineer to the surface as necessary. Minimize the amount of water added to the PCC surface to aid in finishing. Add an evaporation retardant or water by misting. Immediately remove excessive amounts of water as determined by the Engineer in a manner acceptable to the Engineer. Do not conduct finishing operations if free water is present on the PCC surface.

Upon completion of the finishing operation, texture the PCC surface as indicated in the Contract Documents. For imprint applications, apply the imprint form after the finishing operation and while the PCC surface is in a plastic stage. Apply the imprint forms perpendicular to the PCC edge or centerline.

Within one (1) hour of PCC placement, protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and

maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer. For colored PCC applications, thin the liquid curing compound in accordance with the manufacturer's instructions and apply at the application rate recommended by the manufacturer.

Apply a damp-proof coating consisting of a primer and damp-proofing material to the non-exposed surfaces of the PCC as directed by the Engineer. Limit all damp-proofing materials to the treated areas. Do not disfigure untreated portions of the stairs with damp-proofing materials. Uniformly apply one (1) coat of primer and two (2) coats of damp-proofing material in accordance with the manufacturer's instructions. Perform damp-proofing in dry weather when the ambient temperature is forty (40) degrees Fahrenheit or above. Allow each coating to dry before applying the next coating in accordance with the manufacturer's recommendations. Allow the damp-proofing to cure in accordance with the manufacturer's recommendations before commencing backfilling operations.

Apply PCC stains in accordance with the manufacturer's recommendations.

(H) Contraction Joints.

Saw or trowel contraction joints at the dimensions and intervals indicated in the Contract Documents. For imprinted applications, locate the contraction joint to coincide with the lines of the imprint whenever possible. Use a straight, chalked line or other reference acceptable to the Engineer for guiding the line of the joint. Sawing shall begin as soon as the PCC has sufficiently hardened to allow sawing without tearing or raveling. Sequence the sawing to prevent random cracking. Route random cracks to a minimum depth of one (1) inch and a maximum width of three-eighths (3⁄8) inch. Seal or apply curing compound to all contraction joints or routed cracks within twenty-four (24) hours of constructing or routing. Clean the contraction joints and routed cracks immediately before sealing operations. Place joint sealant in the sawed contraction joint and routed cracks to one-fourth (¼) inch below the PCC surface.

(I) Construction Joints.

Construct construction joints to the dimensions indicated in the Contract Documents. Clean the construction joint immediately before sealing operations. Place joint sealant in the sawed construction joint to one-fourth (¼) inch below the PCC surface.

(J) Defective or Substandard PCC.

Remove and replace in accordance with the Contract Documents any portion(s) of the PCC placement that contains random cracking, plastic

shrinkage cracking, scaling, spalls, honeycombs, high spots, depressions, or other defects or substandard conditions as determined by the Engineer. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

The maximum allowable deviation from plane is one-half (½) inch in any ten (10) foot span. The maximum allowable deviation from the specified elevation is minus zero (-0), plus one-half (+½) inch. The maximum allowable deviation for horizontal alignment is one (1) inch. The maximum allowable deviation for horizontal alignment at tie-in locations is one-half (½) inch.

(K) Soil Backfill.

Backfill stairs using soil, granular material, or other materials acceptable to the Engineer. Place the backfill material evenly on each side of the pipe and uniformly across the trench or pit. Backfill material shall not contain frozen lumps, stones greater than two (2) inches in diameter, chunks of highly plastic clay, or other objectionable material unless approved by the Engineer in writing. Using equipment and methods acceptable to the Engineer, compact the backfill uniformly in lifts not exceeding six (6) inches in compacted thickness without damaging the pipe. Do not backfill PCC stairs until the PCC has a minimum compressive strength of three thousand (3,000) pounds per square inch. Avoid damaging any damp-proofing coating during backfilling. Immediately repair any damage to the damp-proof coating in a manner acceptable to the Engineer.

Compact the backfill material uniformly to produce a surface that does not yield under repeated loading by heavy trucks or equipment. Construct the backfill to meet the requirements of Table 608.02. The maximum dry density (Standard Effort) and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). The maximum dry density (Modified Effort) and optimum moisture shall be determined by ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

Table 608.02
Backfill Requirements

Depth Below Pavement or Finished Grade	Minimum Compaction Requirement	Acceptable Moisture Range
≤ 1 foot	92% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%
Greater than 1 foot	95% of Maximum Dry Density (**Standard** Effort)	Optimum Moisture Content –3%, +4%

Manipulate, intermix with borrow materials, or replace with borrow materials any existing materials having a moisture content outside the acceptable range. Continue backfilling operations until the top of the backfill is even with the adjacent ground surface. Place topsoil in the

upper six (6) inches for locations outside the limits of pavement construction unless otherwise directed by the Engineer. When requested by the Engineer, expose select locations for compaction and moisture content testing. Exposing such locations is incidental to the work. Rework or remove and replace any materials that do not comply with the above requirements.

608.04 Measurement and Payment.

The Engineer shall measure PCC stairs for payment as a single unit defined as the number of cubic yards of PCC for PCC stairs placed, finished, and accepted.

Unless otherwise indicated in the Contract Documents, all costs associated with excavation and/or over-excavation for installation of the structure; protection of an excavation; de-watering; supplying additional material for completion of backfilling operations; manipulation of existing materials; intermixing of existing materials with borrow materials, replacing existing materials with borrow materials; removal of fencing or trees; replacement of fencing removed to facilitate construction; and/or repair of damaged damp-proof coating are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for all reinforcement, PCC, and finishing; and for all labor, equipment, tools and incidentals necessary to complete the work.

Description	Unit
Reinforced PCC Stairs	Cubic Yard

609 – RAILINGS

609.01 Description.

This work includes furnishing and erecting steel or aluminum railing and ornamental handrail at the locations indicated in the Contract Documents or as directed by the Engineer.

609.02 Material Requirements.

(A) Structural, Eyebar, Bolt, and Rivet Steel.
Structural and eyebar steel shall conform to the requirements of ASTM A36, Standard Specification for Carbon Structural Steel. High strength, low-alloy steel shall conform to the requirements of ASTM A588, Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi [345 MPa] Minimum Yield Point to 4-in. [100-mm] Thick. The supplementary impact requirements of S1 steel shall apply for all main stress-carrying members used in welded applications. Do not use Grade D or E steel for welded applications without providing satisfactory proof of weldability and obtaining written permission by the Engineer. Low carbon bolts shall conform to the requirements of ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength. All steel used in main tension members shall meet the requirements of the longitudinal Charpy V-notch Test as defined in ASTM A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products. Sampling procedures shall comply with ASTM A673, Standard Specification for Sampling Procedure for Impact Testing of Structural Steel.

(B) Malleable Castings.
Malleable iron castings shall conform to the requirements for Grade 35018 as defined by ASTM A47, Standard Specification for Ferritic Malleable Iron Castings.

(C) Steel Pipe for Railings.
All steel pipe used for railings shall conform to the requirements for standard weight pipe as defined by ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

(D) Aluminum Railings.
Aluminum castings shall conform to the requirements for Alloy S7A as defined by ASTM B108, Standard Specification for Aluminum-Alloy Permanent Mold Castings. Aluminum tubing shall conform to the requirements for Alloy 6061-T6 as defined by ASTM B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes, except that a minimum elongation of ten (10) percent is required.

(E) Cast Iron Capacity Plates.
Cast iron for capacity plates shall conform to the requirements for Class 20 castings as defined by ASTM A48, Standard Specification for Gray Iron Castings.

(F) Aluminum Capacity Plates.
Cast aluminum alloy for capacity plates shall conform to the requirements for Alloy S7A, Condition T6 as defined by ASTM B108, Standard Specification for Aluminum-Alloy Permanent Mold Castings.

(G) Aluminum-Filled, Resilient, Sealing Compound.
Aluminum-filled, resilient sealing compound shall be Minnesota Mining and Manufacturing Company (3M) Sealant Number 1168 or approved equal.

(H) Aluminum Ornamental Handrail.
Fabricate aluminum ornamental handrail in accordance with the Contract Documents or as directed by the Engineer using shapes, plates, castings, and anchorage devices. Shear, saw, or mill all material one-half (½) inch or less in thickness. Saw or mill all material over one-half (½) inch in thickness. Cut edges shall be true and free of burrs or ragged breaks. Fillet reentrant cuts by drilling before cutting. Do not flame cut aluminum material. Heat material before bending to a maximum temperature of four hundred (400) degrees Fahrenheit for a period not exceeding fifteen (15) minutes. Drill or sub-punch bolt holes a minimum of one-eighth ($^1/_8$) inch smaller than the nominal diameter and reamed to size. Limit the finished diameter of the holes to a maximum diameter of seven (7) percent greater than the nominal diameter of the fastener unless otherwise indicated in the Contract Documents. The Engineer reserves the right to reject material having marred or scarred surfaces that in the opinion of the Engineer results in an objectionable appearance. Treat all areas where aluminum contacts PCC using an aluminum-filled, resilient, sealing compound.

(I) Steel Ornamental Handrail.
Steel ornamental handrail shall consist of cast or structural steel posts, steel shapes, plates, and other material as required by the Contract Documents or as directed by the Engineer. All materials shall be galvanized as required by the Contract Documents or as directed by the Engineer. Finish the front face of cast posts in the direction of the vertical axis. The finished surface shall have a surface roughness rating of one hundred twenty-five (125) or better when measured in accordance with ASTM A802, Standard Practice for Steel Castings, Surface Acceptance Standards, Visual Examination. Use sheet lead for all shim materials.

(J) Anchor Bolts.
Bolt, nut, and washer material shall conform to the requirements for Type 3 bolts as defined by ASTM A325, Standard Specification for

Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.

609.03 Construction Requirements.

Use equipment, tools, and machinery designed for and having sufficient capacity for the intended use. Paint all exposed metal using paint and methods acceptable to the Engineer unless galvanizing or other finish methods is specifically required by the Contract Documents or the Engineer. Use the same type and manufacturer for all railing on a project unless otherwise allowed by the Contract Documents or the Engineer.

Construct railings along the lines and grades indicated in the Contract Documents or as directed by the Engineer. Install rail posts plumb unless otherwise indicated in the Contract Documents or as directed by the Engineer. Dress areas to receive rail posts to provide for an even bearing. Repair any damage to the galvanized coating in accordance with the manufacturer's recommendations.

Trim washers as necessary to meet available clearances. Do not trim washers closer than ninety (90) percent of the bolt diameter from the center of the washer. Where bearing faces of bolted parts are not parallel, use beveled washers.

609.04 Measurement and Payment.

The Engineer shall measure ornamental handrail for payment as a single unit defined as the number of linear feet of ornamental handrail supplied, constructed, and accepted. The Engineer shall conduct measurements from center of end post to center of end post as identified in the Contract Documents and along the slope of the rail. Overhang or end sections are subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure handrail for steps for payment as a single unit defined as the number of linear feet of handrail for steps supplied, constructed, and accepted. The Engineer shall conduct measurements from center of end post to center of end post as identified in the Contract Documents and along the slope of the rail. Overhang or end sections are subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure structural steel for handrail or bridge rail for payment as a single unit defined as the number of pounds of structural steel supplied, constructed, and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for all materials, fabrication, shop work, transportation and erecting; for all paint, painting and galvanizing; and for all labor, equipment, tools and incidentals necessary to complete the work.

Description	Unit
___ Ornamental Handrail	Linear Foot
___ Handrail for Steps	Linear Foot
___ Bridge Rail	Linear Foot
Structural Steel for ___ Rail	Pound

700 SEWER/SUBSURFACE CONSTRUCTION

701 – SEWER CONSTRUCTION

701.01 Description.

This work includes furnishing and constructing sewers and appurtenances along the lines and grades indicated in the Contract Documents or as directed by the Engineer.

701.02 Material Requirements.

(A) General Classification of Materials.
Rigid Pipe includes but is not limited to PCC, Ductile Iron, Vitrified Clay, Fiberglass, and PVC Truss as specified hereinafter. Flexible pipe is defined as any pipe having a pipe stiffness of one hundred fifty-three (153) pounds per inch per inch or less. Flexible Pipe includes but is not limited to Corrugated Steel, Corrugated Aluminum, Solid Wall PVC, Corrugated PVC, and Profile Wall PVC as specified hereinafter. The Engineer shall determine whether a pipe material not listed in this specification, or a pipe material that is listed but is substantially different from the specification, is rigid or flexible.

(B) Storm Sewer Materials.
The following materials are generally approved for storm sewer construction: PCC Pipe; Ductile Iron Pipe; and Vitrified Clay Pipe. Do not use materials other than those specifically identified in this paragraph for storm sewer construction unless otherwise indicated in the Contract Documents or authorized in writing by the Engineer.

(C) Sanitary and Combined Sewer Materials.
For the purposes of specifying materials and installation procedures or requirements, consider combined sewers the same as sanitary sewers. The following materials are generally approved for sanitary and combined sewer construction: PCC Pipe; Ductile Iron Pipe; Vitrified Clay Pipe; PVC Composite Truss Pipe, Solid Wall PVC, Corrugated PVC, and Profile Wall PVC as specified hereinafter. Do not use materials other than those specifically identified in this paragraph for sanitary sewer construction unless otherwise indicated in the Contract Documents or authorized in writing by the Engineer.

(D) Culvert Materials.
The following materials are generally approved for culvert construction: PCC, Ductile Iron, Vitrified Clay, Fiberglass, Asbestos-Cement, Corrugated Steel, Corrugated Aluminum, and PVC Truss as specified hereinafter. Do not use materials other than those specifically identified in this paragraph for culvert construction unless otherwise

indicated in the Contract Documents or authorized in writing by the Engineer.

(E) PCC Pipe, Fittings, and Outlet Structures.

Non-reinforced concrete circular pipe, fittings, and outlet structures shall conform to the requirements of ASTM C14, Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe, or ASTM C985, Standard Specification for Nonreinforced Concrete Specified Strength Culvert, Storm Drain, and Sewer Pipe.

Reinforced PCC circular pipe, fittings, and outlet structures with a diameter less than or equal to thirty (30) inches shall be Class III, Wall B or C pipe as defined by ASTM C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe. Reinforcement may be circular or elliptical. Mark elliptically reinforced pipe to illustrate proper installation.

Circular reinforced PCC pipe, fittings, and outlet structures with a diameter greater than thirty (30) inches shall be Class III, Wall B or C pipe as defined by ASTM C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe or D-Load pipe as defined by ASTM C655, Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe. Reinforcement may be circular or elliptical. Mark elliptically reinforced pipe to illustrate proper installation.

Reinforced PCC arch pipe, fittings, and outlet structures shall meet the requirements for Class A-III pipe as defined by ASTM C506, Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe. Reinforcement shall be single or double line.

Reinforced PCC elliptical pipe, fittings, and outlet structures shall meet the requirements for Class HE-III or Class VE-III as defined by ASTM C507, Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe. Reinforcement shall be single or double cage.

Reinforced PCC box sections shall conform to the requirements of ASTM C1433, Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers.

Reinforced PCC pipe, fittings, and joints for jacking or boring and jacking applications shall conform to the requirements of ASTM C361, Standard Specifications for Reinforced Low-Head Pressure Pipe.

Splicing of reinforced PCC pipe is allowed if both portions of the splice are cut in such a manner that does not compromise the structural integrity of the PCC pipe. Splice the pipe by exposing and welding the reinforcement steel at all junctions and miters and rebuilding the wall

section to the minimum required thickness using mortar or PCC that will achieve the same hardened properties as the reinforced PCC pipe.

Portland cement for storm sewer applications shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 2 (Maximum Equivalent Alkalies requirements only) and Table 3. Portland cement for sanitary and combined sewer applications shall conform to the requirements for Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 2 (Maximum Equivalent Alkalies requirements only) and Table 3.

Pipe joints for storm sewer pipe shall conform to ASTM C990, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants. Joints may also be a cold applied, bitumastic joint filler acceptable to the Engineer. Cold applied bitumastic material shall not be pre-applied to pipe sections. Material must be applied within four hours of installing pipe. The minimum quantity of joint compound to be applied is as shown in Table 701.01a. Follow manufacturer's recommendations for pipe larger than 72" in diameter.

Table 701.01a
Mastic Requirements for Concrete Pipe Joints

Pipe Size	Mastic Lbs./jt.	Joints per 50 lb. Bucket	Pipe Size	Mastic Lbs./jt.	Joints per 50 lb. Bucket
12"	1.75	28	36"	18.7	2.5
15"	2.77	18	42"	24.37	2
18"	4.12	12	48"	29.63	1.5
21"	5.98	8	54"	45.02	1
24"	7.83	6	60"	59.13	.75
27"	10.76	4.5	66"	74.26	.66
30"	13.7	3.5	72"	91.6	.5

Pipe joints for all sanitary sewer pipe shall a fabricated gasket type joint. The gasket shall conform to the requirements of ASTM C361, Standard Specifications for Reinforced Low-Head Pressure Pipe."

Resilient connectors for reinforced PCC pipe shall conform to the requirements of ASTM C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals, or ASTM C1478, Standard Specification for Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipes and Laterals.

(F) Corrugated Steel Pipe, Fittings, and Outlet Structures.
Corrugated steel pipe, fittings, and outlet structures shall be pre-coated, post-coated, or lined. Pre-coated corrugated steel pipe shall conform to the requirements of ASTM A762, Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains, or AASHTO M274, Steel Sheet, Aluminum-Coated (Type 2), for Corrugated Steel Pipe. Pre-coated steel structural plate pipe shall conform to the requirements of ASTM A761, Standard Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches. Post-coated or bituminous- or PCC-lined corrugated steel pipe shall conform to the requirements of ASTM A849, Standard Specification for Post-Applied Coatings, Pavings, and Linings for Corrugated Steel Sewer and Drainage Pipe. Clean pipes before applying the coating. Apply coating in accordance with ASTM A862, Standard Practice for Application of Asphalt Coatings to Corrugated Steel Sewer and Drainage Pipe. Precoated polyethylene-lined steel pipe shall conform to the requirements of ASTM A978, Standard Specification for Composite Ribbed Steel Pipe, Precoated and Polyethylene Lined for Gravity Flow Sanitary Sewers, Storm Sewers, and Other Special Applications. Miscellaneous hardware shall conform to the requirements of ASTM A449, Standard Specification for Quenched and Tempered Steel Bolts and Studs

Pipe gaskets for the pipe shall conform to the requirements of ASTM D1056, Standard Specification for Flexible Cellular Materials-Sponge or Expanded Rubber, for the "RE" closed cell grades. The minimum width of coupling bands shall conform to the requirements of the pipe manufacturer.

(G) Corrugated Aluminum Pipe, Fittings, and Outlet Structures.
Corrugated aluminum pipe, fittings, and outlet structures shall conform to the requirements of ASTM B745, Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains, or ASTM B746, Standard Specification for Corrugated Aluminum Alloy Structural Plate for Field-Bolted Pipe, Pipe-Arches, and Arches. Bituminous coatings shall conform to the requirements of AASHTO M 190, Bituminous-Coated Corrugated Metal Culvert Pipe and Pipe Arches.

Pipe gaskets for the pipe shall conform to the requirements of ASTM D1056, Standard Specification for Flexible Cellular Materials-Sponge or Expanded Rubber, for the "RE" closed cell grades. The minimum width of coupling bands shall conform to the requirements of the pipe manufacturer.

(H) Ductile Iron Pipe, Fittings, and Outlet Structures.
Ductile iron pipe, fittings, and outlet structures shall conform to the requirements of ASTM A746, Standard Specification for Ductile Iron Gravity Sewer Pipe. Ductile iron pipe used for Sanitary Sewer shall have a factory-applied bitumastic or H_2S resistant cement grout liner.

Joints shall conform to A21.11 ANSI Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

(I) Vitrified Clay Pipe, Fittings, and Outlet Structures.
Vitrified clay pipe, fittings, and outlet structures shall conform to the requirements of ASTM C700, Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.

Vitrified clay pipe for microtunneling, slip lining, and pipe bursting shall conform to the requirements of ASTM C1208, Standard Specification for Vitrified Clay Pipe and Joints for Use in Microtunneling, Slip Lining, Pipe bursting, and Tunnels.

Compression joints for vitrified clay pipe shall conform to the requirements of ASTM C425, Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.

(J) PVC Pipe, Fittings, and Outlet Structures.
All PVC pipe and fittings having an inside diameter of less than or equal to six (6) inches shall have a minimum pipe stiffness of one hundred fifty three (153) pounds per inch per inch. Flexible PVC pipe and fittings having an inside diameter greater than or equal to eight (8) inches shall have a minimum pipe stiffness of forty-six (46) pounds per inch per inch.

Solid wall PVC pipe, fittings, and outlet structures having an inside diameter of fifteen (15) inches or less shall meet the requirements of ASTM D3034, Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

Solid Wall PVC pipe, fittings, and outlet structures having an inside diameter of eighteen (18) inches to twenty-seven (27) inches shall conform to the requirements of ASTM F 679, Standard Specification for Poly(Vinyl Chloride)(PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.

PVC composite truss pipe, fittings, and outlet structures shall have a minimum pipe stiffness of two hundred (200) pounds per inch per inch and shall conform to the requirements of ASTM D2680, Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping.

Corrugated PVC pipe, fittings, and outlet structures shall conform to the requirements of ASTM F949, Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe With a Smooth Interior and Fittings.

Profile Wall PVC pipe, fittings, and outlet structures shall conform to the requirements of ASTM F794, Standard Specification for

Poly(Vinyl Chloride)(PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter, or ASTM F1803, Standard Specification for Poly(VinylChloride) (PVC) Closed Profile Gravity Pipe and Fittings Based on Controlled Inside Diameter.

Pipe gaskets for plastic pipe shall conform to the requirements of ASTM D3212, Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals, and ASTM F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

(K) Fiberglass Pipe, Fittings, and Outlet Structures.

Fiberglass pipe, fittings, and outlet structures conform to the requirements of ASTM D3262, Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe, and ASTM D3840, Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Fittings for Nonpressure Applications.

Joints shall be as recommended by the manufacturer and subject to the engineer's approval.

(L) Wye and Tee Branches.

Wye and tee branches shall conform to the specifications of the sewer pipe used. For wyes used in sanitary sewers systems to connect to private sewer laterals, the minimum diameter of a wye branch shall be six (6) inches.

(M) Flared End Sections – General.

Flared end sections shall be integral units that connect as a continuation of the sewer pipe using standard joints.

(N) Pipe Couplings.

Flexible transition couplings shall conform to the requirements of ASTM C1173, Standard Specification for Flexible Transition Couplings for Underground Piping Systems.

Stainless steel, shielded rubber couplings shall consist of a gasket, shear ring, and tightening bands acceptable to the Engineer. Couplings for pipe having an outside diameter of twelve (12) inches or less shall be at least six (6) inched wide. Couplings for pipe having an outside diameter greater than twelve (12) inches shall be at least ten (10) inched wide. Gaskets shall conform to the requirements of Table 2 of ASTM C-425, Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings. Shear rings shall be series 300 SS with a minimum thickness of .012". Tightening bands and bolts shall be series 316 SS. Shear rings and clamps shall conform to the requirements of ASTM A-240, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

For coupling bands used on metal pipe, the coupling bands shall be comprised of the same material as the pipe. The minimum width of the coupling band for pipes having and outside diameter of thirty (30) inches or less shall be ten (10) inches. The minimum width of the coupling band for pipes having an outside diameters greater than thirty (30) inches and less than or equal to fifty-four (54) inches shall be twelve (12) inches. Install the bands to lap an equal portion on each of the adjoining pipe sections. Connect the band segment ends using galvanized angles having minimum dimensions of two (2) inches by two (2) inches by three-sixteenths ($^{3}/_{16}$) inch. Use a minimum of two (2) one-half (½) inch galvanized bolts for connecting ten (10) inch bands and three (3) one-half (½) inch galvanized bolts for connecting twelve (12) inch bands

(O) Joint Mortar and Joint Filler.

Pipe joint mortar shall consist of one part Portland cement and two parts sand. The Portland cement shall conform to the requirements for Cement Type I as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2, and Table 4. The sand shall conform to the requirements of ASTM C144, Standard Specification for Aggregate for Masonry Mortar.

Poured filler for joints shall conform to the requirements of ASTM D1190, Standard Specification for Concrete Joint Sealer, Hot-Applied Elastic Type.

(P) Aggregate Bedding Material.

Aggregate bedding material shall consist of recycled PCC, crushed limestone, quartzite, or dolomite meeting the requirements for Class 1S coarse aggregate as defined by ASTM C33, Standard Specification for Concrete Aggregates. The bedding material shall conform to the gradation requirements of Table 701.01.

Table 701.01
Aggregate Gradation Requirements

	≤18 inch Diameter Pipe Nominal Max. Size ¾-inch	**≤ 60 inch Diameter Pipe Nominal Max. Size 1 ½-inch**	**> 60 inch Diameter Pipe Nominal Max Size 2 or 3-inch**
Sieve Size	**Percent Passing**		
2 ½ inch			80 +/- 20
1 ½ inch		100	40 +/- 20
¾ inch	100	80 +/- 15	20 +/- 20
3/8 inch	60 +/- 15	53 +/- 17	5 +/- 5
#4	40 +/- 20	25 +/- 20	
#10	15 +/- 10	20 +/- 10	
#200	< 8	< 8	

(Q) PCC for Pipe Cradles, Encasements, and Collars.

PCC for pipe cradles, encasements, and collars shall meet the requirements of ASTM C94, Standard Specification for Ready-Mixed Concrete, and shall have a minimum twenty-eight (28) day compressive strength of three thousand five hundred (3,500) pounds per square inch.

Reinforcing steel shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

Curing materials shall be membrane-forming compounds or polyethylene film. Liquid membrane-forming compounds for curing PCC shall conform to the requirements for Type 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

(R) Bar Grates.

Bar grates shall conform to the requirements of ASTM A36, Standard Specification for Carbon Structural Steel. Galvanize the bar grates in accordance with ASTM A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. Dimension the bar grates in accordance with the Contract Documents or as directed by the Engineer.

(S) Steel Casing for Bore and Jack Applications.

Steel casing shall conform to the requirements of ASTM A139, Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over), with a minimum diameter as shown on the plans. Unless otherwise noted in the Contract Documents, the minimum wall thickness shall conform to the requirements of Table 701.02a. Use Grade A steel for all applications unless otherwise indicated in the Contract Documents. Steel casing installed under railroads shall conform to the requirements of the railroad owner. The wall thickness of casings larger than 36 inches in diameter shall meet the requirements of the railroad owner.

Table 701.02a
Steel Casing Wall Thickness

Dia. Of Casing	Nominal wall Thickness (inches) Under Railroads		
(Inches)	Main Line	Branch Line	All other uses
24	0.375	0.3125	0.281
26	0.375	0.375	0.281
28	0.375	0.375	0.312
30	0.4375	0.375	0.312
32	0.4375	0.4375	0.312
34	0.500	0.4375	0.312
36	0.500	0.4375	0.344

(T) Borrow Materials.

Borrow material shall consist of silty clay (CL-ML) or lean clay (CL) materials as determined in accordance with ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes. Borrow material shall be free of debris, vegetation, aggregate greater than two (2) inches in diameter, or organic matter. The Engineer must approve all borrow material in writing before use by the Contractor.

(U) Flowable Fill.

Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2, and Table 4.

Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Keep fine aggregate materials moist for twenty-four (24) hours before use in the mixture.

Fly ash shall conform to the requirements of Class C Fly Ash as defined by ASTM C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.

All water used in the flowable fill mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. An accredited laboratory shall certify that each admixture meets the requirements of the

appropriate ASTM Designation. Dosages shall be as directed by the manufacturer.

Prepare and submit a flowable fill mix design that identifies the component materials, the proportion of such materials, the twenty-eight (28) day compressive strength, and the air content. Flowable fill shall have a twenty-eight (28) day compressive strength of seventy-five plus or minus fifty (75±50) pounds per square inch and an air content of ten plus or minus three (10±3) percent. Proportion the materials to produce a mixture with a consistency that flows under a very low head.

(V) Sewer Pipe Manufacturing Facilities..

The Engineer has the right to inspect any sewer pipe manufacturing facility that intends to provide pipe on City projects. Furthermore, upon written request by the Engineer, the manufacturer will submit a detailed written narrative describing their manufacturing and quality control/assurance processes. Based on either the on-site inspection of the facility or the review of the written procedures, the Engineer, at his sole discretion, may reject pipe manufactured from the facility.

701.03 Construction Requirements.

(A) General.

Unless otherwise indicated in the Contract Documents, install pipe using open-cut excavation in accordance with the following requirements. The Engineer shall resolve any conflicts.

(B) PCC Pipe Installation.

Install PCC pipe in accordance with the requirements for a Type 3 installation as defined by ASTM C1479, Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations. Pipe shall be installed in accordance with the requirements for a Type 1 or Type 2 installation if so indicated on the plans or called for in the Supplemental Specifications.

(C) Steel Pipe Installation

Install steel pipe in accordance with ASTM A798, Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications. Install steel structural plate pipe in accordance with ASTM A807, Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications.

(D) Corrugated Aluminum Pipe Installation.

Install aluminum pipe in accordance with ASTM B788, Standard Practice for Installing Factory-Made Corrugated Aluminum Culverts and Storm Sewer Pipe. Install aluminum structural plate pipe in accordance with ASTM B789, Standard Practice for Installing Corrugated Aluminum Structural Plate Pipe for Culverts and Sewers.

(E) Ductile Iron Pipe Installation.
Install iron pipe in accordance with AWWA C600, Installation of Cast Iron Water Mains.

(F) Vitrified Clay Pipe Installation.
Install vitrified clay pipe in accordance with ASTM C12, Standard Practice for Installing Vitrified Clay Pipe Lines.

(G) PVC Pipe Installation.
Install PVC pipe in accordance with ASTM D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

(H) Fiberglass Pipe Installation.
Install fiberglass pipe in accordance with ASTM D3839, Standard Practice for Underground Installation of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.

(I) Excavation.
Using equipment designed for the intended use and acceptable to the Engineer, excavate the trench to the lines, grades, and tolerances required by the Contract Documents or as directed by the Engineer. Begin excavating trenches at the outlet end and proceed toward the upper end, true to the required line and grade. Do not begin the excavation for pipes placed in embankment until completing such embankment to an elevation above or equal to the top of the pipe. The maximum allowable length of an open or unfilled trench shall be three hundred (300) feet. The Engineer reserves the right to further limit the maximum allowable length as deemed necessary. Protect all unattended excavations from entry by non-authorized personnel using fencing or other means acceptable to the Engineer. The maximum allowable length of an open or unfilled trench at the completion of the working day or when operations are suspended for a period longer than four (4) hours shall be twenty-five (25) feet. Stockpile topsoil materials separately when Contract Documents require topsoil placement atop the backfill.

Protect excavations in accordance with the requirements of 29CFR Part 1926, Safety and Health Regulations for Construction. Provide all sheathing, bracing, piling, and shoring necessary to protect the excavation and all adjacent structures. Any damage to the work or to adjacent structures resulting from failure of excavation walls will be the Contractor's responsibility. The cost of protection of excavations or structures is subsidiary to items for which the Contract provides direct payment. Do not excavate beyond the bottom elevation indicated in the Contract Documents of any footings, walls, floors, etc., of an adjacent structure without written approval from the Engineer. Do not protect excavations by sloping without written permission from the Engineer.

Excavate trenches for installing pipe to the lines and grades indicated in the Contract Documents or as directed by the Engineer. The excavated trench shall be wide enough to allow thorough tamping of the backfill adjacent to the lower portion of the pipe. The minimum width of the trench shall be two (2) feet wider than the maximum horizontal width of pipe. Over-excavate any unsuitable material as directed by the Engineer. Replace over-excavated material using crushed rock bedding.

Accomplish excavating in a manner that does not create collected or standing water at any place on the site during construction. De-water in a manner acceptable to the Engineer as necessary. Accomplish de-watering without damaging any downstream conveyance or properties.

Over-excavate below the lower surface of the pipe when the Engineer determines that the soils encountered will not provide adequate support for the pipe. Over-excavate to a width and depth as determined by the Engineer. Do not excavate below the depths indicated. Replace over-excavated material to the established elevation using crushed rock compacted to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). Replace unnecessary over-excavation at no additional cost to the City.

(J) Bore and Jack Installation.

Construct bored and jacked pipes or casing of the size indicated in the Contract Documents or as directed by the Engineer using crews and/or firms acceptable to the Engineer. When requested by the Engineer, submit detailed information on the superintendent, crew, and equipment to be used in the boring and jacking operation before commencing the work.

Before starting work, submit complete details of the proposed method of operation, proposed equipment, and liner materials to the Engineer. Experienced crews acceptable to the Engineer shall perform boring operations using a machine designed especially for rotary type boring. Protect existing structures, utilities, trees, or other similarly permanent objects before and during the bore and jack operation. Provide positive surface drainage away from the excavated pit that avoids temporary or permanent damage to adjacent property in a manner acceptable to the Engineer. Repair any damage resulting from the bore and jack operation at no additional cost to the City. Provide de-watering and chemical soil stabilization or grouting operations as required by field conditions or directed by the Engineer.

Conduct horizontal boring using a dry boring method that avoids disturbing the overlying or adjacent material. Do not use boring methods that use water without written permission from the Engineer.

Remove and stockpile or dispose of materials excavated during the boring or jacking operation to avoid or prevent flow of material into the pipe. Install steel casing immediately following the excavation. Install steel casings as required by the Contract Documents. Weld adjacent sections of steel casing together before installing. All welding shall conform to the requirements set forth in AWS D2.0, Specifications for Welded Highway and Railway Bridges. Advance casing continuously with excavation. Install jacking pipe using mechanical or push-on joints to connect adjacent sections of pipe. Maintain alignment, grade, and shape of the casing or jacking pipe. When installing steel casing or jacking pipe under railroad tracks, center one (1) section of the casing or pipe on the centerline of each set of tracks. Remove all debris from the steel casing or jacking pipe upon completion of the installation. Install the sewer pipe without damaging the pipe or pipe joints. Fill the gap between the sewer pipe and the steel casing using sand or other materials acceptable to the Engineer after leak testing the sewer pipe. Do not disturb the alignment or grade of the sewer pipe.

(K) Pipe Bedding - General.

Rigid pipe bedding shall consist of soil bedding, aggregate bedding, or construction of a continuous PCC cradle. Flexible pipe bedding shall consist of aggregate bedding.

Do not utilize soil bedding unless specifically indicated in the Contract Documents and approved by the Engineer. Soil bedding shall consist of shaping the trench to match the bottom of the pipe for at least the lower ten (10) percent of the total pipe height. Shape the bed to fit the pipe and any bell or connecting bands. Spread a one (1) to two (2) inch layer of pulverized soil or fine gravel across the bottom

Table 701.02 illustrates the minimum bedding depth required beneath the lowest point of the pipe. Aggregate bedding material shall extend the full width of the trench, and up to the vertical center of the pipe. Place a minimum of twelve (12) inches of additional aggregate bedding material above the highest point of all flexible pipes. Place additional material above or below the pipe as recommended by the pipe manufacturer, or as necessary to meet installation requirements. Place the aggregate bedding material in six (6) inch maximum lifts compacted to a minimum of ninety-five (95) percent of the maximum density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).

Table 701.02
Aggregate Bedding Depth

Nominal Pipe Diameter (Inches)	Rigid Pipe Minimum Depth (Inches)*	Flexible Pipe Minimum Depth (Inches)
Less than or Equal to 12	**	6
Less than or Equal to 30	6	6***
Less than or Equal to 60	12	12***
Greater than 60	18	N/A

* See ASTM C1479 for minimum depth for PCC pipe.
** As required by the Engineer
*** Or one-fourth (¼) of the diameter, whichever is greater.

Construct a continuous PCC cradle in accordance with the Contract Documents or as directed by the Engineer.

(L) General Sewer Pipe and Appurtenances Installation.
Install all pipe and appurtenances in accordance with the following. The Engineer shall resolve any conflicts between installation requirements. Install pipe and appurtenances at the locations and along the lines and grades indicated in the Contract Documents or as directed by the Engineer. Verify the line and grade of the pipe using equipment or methods acceptable to the Engineer.

Begin at the lowest point of the trench and proceed upgrade. Complete all bore and jack pipe installation before commencing installation of open trench connections. Handle and place the pipe in a manner that avoids damaging the pipe, flared end section, or bedding material. Before placing pipe or flared end section in the trench, inspect for cracks or other defects. Defective pipe must not be installed and must be disposed of off site. Do not support pipe or flared end sections using blocks except when encasing in PCC.

Place the pipe or flared end section into the trench with the bell or groove end or the outside circumferential lap facing upgrade. Verify that each segment of the pipe or flared end section contacts the bedding material throughout the full length. Assemble the pipe in its nominal closed position with the adjacent section. Place paved or partially lined pipe so that the longitudinal center line of the paved or lined segment coincides with the flow line. Place elliptical and elliptically reinforced pipes with the manufacturer's top of pipe mark within five (5) degrees of the longitudinal axis of the pipe.

Install pipe sections only when weather and soil conditions are suitable. Prevent foreign matter from entering the pipe during periods of inactivity in a manner acceptable to the Engineer. Take all measures necessary to prevent water from filling the trench and conduct operations in a manner that prevents pipe flotation. Remove water, sand, mud, and other undesirable materials from the trench before

removal of end cap. Brace or anchor pipe section as required to prevent displacement after establishing final position.

Locate joints to provide for differential movement due to changes in type of pipe bedding or the presence of concrete collars or structures. Clean the interior of all pipe, fittings, and joints before installation. Use lubricants, primers, adhesives, tools, methods, and equipment as recommended by the pipe or joint manufacturer. Check the compliance of the joint opening, deflection, and gasket position before installing the next pipe section. Cut pipe in a neat workman-like manner using approved methods and equipment as necessary. Smooth cuts by power grinding to remove burrs and sharp edges. Repair any damage to the lining in accordance with the manufacturer's recommendation.

Form curves by placing pipe segments on tangential elements to the radii curve whenever possible. Do not exceed the maximum alignment angle recommended by the pipe or joint manufacturer. Provide and install beveled, bent, or other special manufacture pipes whenever tangential placement fails to fulfill the required radius requirements. The manufacturer shall match-mark any specially-manufacturer pipe before delivery to the project.

Do not make more than one (1) correction for alignment or grade between manholes, inlet, or other similar structures. The maximum allowable tolerance for installation is 25% of the inside pipe diameter or one foot, whichever is less, for horizontal alignment. The maximum allowable tolerance for installation in the vertical alignment is 0.08 foot. The maximum allowable joint deflection shall be five (5) percent. Use a lower maximum allowable joint deflection when recommended by the pipe manufacturer. Remove, replace as necessary, and relay or otherwise repair any sections of non-conforming pipe at no additional cost to the City unless otherwise directed by the Engineer.

(M) Pipe Joints.

Apply and install pipe joints in accordance with the joint material manufacturer’s recommendations. Joints used for storm sewer construction shall resist soil infiltration. Joints used for sanitary or combined sewer construction shall be watertight.

(N) PVC Pipe Joints.

PVC pipe joints shall be watertight and shall consist of elastomeric seals or other materials acceptable to the Engineer. When flowable fill is used, all joints shall have gaskets.

(O) Wye Branches.

Install wye branches at the locations indicated in the Contract Documents or identified by the Engineer in accordance with the requirements for installation of the adjacent pipe.

(P) Connections to Existing Pipelines and Structures.

Connect the pipe to existing structures or pipelines at the locations indicated in the Contract Documents or identified by the Engineer using watertight jointing methods and materials acceptable to the Engineer. Construct connections between jacked pipe and other pipe of different material using a PCC collar. Use adapters and concrete collars at the locations indicated in the Contract Documents or identified by the Engineer. Prepare existing structures by cutting or otherwise constructing an opening with a minimum clearance of two (2) inches on all sides. Position the pipe and fill the opening between pipe and the structure using an expansive grout, rubber gasket, plastic gasket, or other material to provide a watertight seal. Install water stops on all plastic pipe as required by the Engineer. When flowable fill is used, all joints shall have gaskets.

(Q) Pipe Cradles, Encasements, and Collars.

Install PCC cradles, total or partial PCC pipe encasements, or PCC collars at the locations identified in the Contract Documents or by the Engineer. Install reinforcing steel as indicated in the Contract Documents. Position and support the pipe using blocks to maintain position and prevent flotation. Erect forms as necessary. Locate construction joints in the encasement to coincide with the pipe joints. Longitudinal reinforcement shall be continuous through construction joints. Protect and cure the PCC after finishing for a minimum of three (3) days. Do not partially encase flexible pipes without written authorization from the Engineer.

(R) Soil Backfill.

Inspect the pipe before commencing backfilling operations to verify that all pipes are undamaged, in the proper alignment, and have not settled. Remove and relay any pipes that have settled or become damaged or out-of-alignment at no additional cost to the City. Do not backfill PCC encasements or collars until the PCC has a minimum compressive strength of three thousand (3,000) pounds per square inch.

Backfill trenches or pits using soil, granular material, or other materials acceptable to the Engineer. Place the backfill material evenly on each side of the pipe and uniformly across the trench or pit. Thoroughly compact material under the pipe haunches. Backfill material shall not contain frozen lumps, stones greater than two (2) inches in diameter, chunks of highly plastic clay, or other objectionable material unless approved by the Engineer in writing. Using equipment and methods acceptable to the Engineer, compact the backfill uniformly in lifts not exceeding six (6) inches in compacted thickness without damaging the pipe. The completed backfill shall not yield under repeated loading by heavy trucks or equipment. Construct the embankment to meet the requirements of Table 701.03. The maximum dry density (Standard Effort) and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of

Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). The maximum dry density (Modified Effort) and optimum moisture shall be determined by ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

Table 701.03
Backfill Requirements

Depth Below Pavement or Finished Grade	Minimum Compaction Requirement	Acceptable Moisture Range
≤ 1 foot (under pavement and within 4 feet of the edge of pavement and under sidewalk/ bike trail	90% of Maximum Dry Density (Modified Effort)	Optimum Moisture Content –3%, +4%
1-5 feet (all excavation widths)	95% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%
> 5 feet (excavation widths < 6 feet)	92% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +6%
> 5 feet (excavation widths ≥ 6 feet)	95% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%
≤ 1 foot (beyond 4 ft of pavement or beyond edge of sidewalk / bike trail	92% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%

Manipulate, intermix with soil materials, or replace with borrow materials any existing materials having a moisture content outside the acceptable range.

When directed by the Engineer, import borrow soils or other materials to adjust the moisture content of the existing soil. The cost for extra materials will be paid for as designated in the Contract Documents.

Continue backfilling operations until the top of the backfill is even with the adjacent ground surface. Place topsoil in the upper six (6) inches for locations outside the limits of pavement construction unless otherwise directed by the Engineer. When requested by the Engineer, expose select locations for compaction and moisture content testing. Rework or remove and replace any materials that do not comply with the above requirements as directed by the Engineer.

(S) Flowable Fill Backfill.

The National Ready Mixed Concrete Association must certify the flowable fill production facility. Mixing times shall conform to the requirements of ASTM C94, Specification for Ready-Mixed Concrete. Hand mixing is not allowed. The production facility shall supply a load ticket with the actual batch weights of component materials.

Inspect the pipe before commencing backfilling operations to verify that all pipes are undamaged, in the proper alignment, and have not settled. Before commencing placement of the flowable fill, take all necessary steps to assure that placement of the flowable fill does not damage or displace the pipe. Remove and relay any pipes that have settled or become damaged or out-of-alignment at no additional cost to the City.

Thoroughly mix all water added at the project site in accordance with the recommendations stated in ACI 305, Hot Weather Concreting. Measure all water added to the mix. Do not exceed the water cement ratio stated in the flowable fill mix design approved by the Engineer. Do not add water after discharge of the flowable fill from the mixer has begun.

Place flowable fill within ninety (90) minutes after the addition of cement or fly ash to the mix. The Engineer reserves the right to reduce the allowable time for placement to account for adverse weather conditions or other factors that may accelerate the stiffening of the mix.

(T) Pipe Acceptance Testing.

Acceptance testing for sewer lines between manholes shall consist of low-pressure air and/or deflection testing as required by the Engineer after installation. Do not permit live wastewater flow in the sanitary sewer until all testing is completed and found acceptable, unless otherwise indicated in the Contract Documents or directed by the Engineer. Use equipment and procedures acceptable to the Engineer. Perform testing on sewer pipe after completing backfill construction and before placement of pavement, sidewalk, or other structures located above the pipe unless otherwise directed by the Engineer. The Engineer reserves the right to allow testing after partially backfilling the pipe if the amount of backfill completed sufficiently stabilizes the alignment and grade of the pipe. Notify the Engineer a minimum of twenty-four (24) hours before scheduling testing. Do not perform any acceptance testing without the Engineer present. Repeat testing after locating and correcting any deficient installations at no additional cost to the City. Contractor shall be responsible for any damage to public or private property caused by failure of pipe plugs.

All Sanitary Sewer pipe 24 inches and smaller in diameter shall be low-pressure air tested. Perform air testing on PCC pipe having an inside diameter up to twenty-four (24) inches in accordance with ASTM C924, Standard Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method. Perform air testing on vitrified clay pipe in accordance with ASTM C828, Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines. Perform air testing on plastic pipe in accordance with ASTM F1417, Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-

Pressure Air. Perform air testing on all other pipe types as directed by the Engineer.

Use a pipe plug equipped with a tap to introduce and regulate air pressure and a tap to measure internal pressure. Taps shall include all valves and fittings. When requested by the Engineer, equip the measuring tap to allow attachment of two (2) pressure test gauges. The pressure test gauge shall have a minimum range of zero (0) to fifteen (15) pounds per square inch, maximum intervals of one (1) pound per square inch, subdivisions of five-hundredths (0.05) pounds per square inch, and an accuracy of plus or minus twenty-five-hundredths (0.25) pounds per square inch. Calibrate pressure test gauges in accordance with the gauge manufacturer's instructions. An independent calibration agency acceptable to the Engineer shall calibrate gauges at a maximum interval of one (1) time every twelve (12) months. Provide the certification of calibration to the Engineer before commencing air testing. Re-calibrate suspect gauges as required by the Engineer.

Perform deflection testing to verify compliance with the maximum allowable vertical deflection on all flexible pipe installations. Perform deflection testing two (2) times on all flexible pipe installations after completion of the backfill; one (1) time after a minimum of thirty (30) days and one (1) time as directed by the Engineer. The pipe shall be free of sewage flow during this test. Perform all by-pass pumping required in order to conduct the deflection test at no additional cost to the City.

Perform deflection testing using a deflectometer that produces a continuous record of pipe deflection or by pulling a mandrel, sphere, or pin-type go/no-go device through the pipeline. Before use, submit the deflectometer or similar device to the Engineer for measurement and approval. Do not use unapproved devices or devices altered after approval without obtaining written authorization from the Engineer. Test results obtained using unauthorized devices will be considered invalid. Pull the deflectometer through the test segment using a pulling force equivalent hand power. Do not apply any excessive forces when pulling the deflectometer that may damage the pipe or erroneously indicate that deflection was within acceptable limits.

Mandrels shall be fabricated of steel with pull rings at each end. Mandrels shall be rigid, nonadjustable, have an odd-number of legs (9 minimum). and have an effective length not less than its nominal diameter. If the mandrel fails to pass through the pipe in accordance with these specifications, the pipe shall be deemed to be over deflected.

The diameter of the deflection testing equipment shall be ninety-five (95) percent of the average inside diameter for the size and type of pipe indicated in the Contract Documents. The maximum allowable ring deflection of the pipeline after installation shall be five (5) percent.

Uncover any pipe deflected greater than the maximum allowable deflection. If the Engineer determines such pipe is undamaged, reinstall the pipe in accordance with the Contract Documents. Remove damaged pipe from the work site and replace such pipe in accordance with the Contract Documents. Accomplish uncovering, removal, replacement, and/or re-installation of deflected pipe at no additional cost to the City.

Remove any soil, debris, or other unwanted material from the sewer line upon completion of installation and any acceptance testing in a manner acceptable to the Engineer.

701.04 Measurement and Payment.

The cost of excavation and over-excavation for installation of pipe; protection of excavations or structures; de-watering and chemical soil stabilization or grouting operations; beveled, bent, or special manufacture pipe; manipulating existing materials, or manipulation and intermixing with borrow materials, or intermixing or manipulation of new materials with the existing soil materials; exposing locations for compaction and moisture content testing; and performing any or all acceptance testing is subsidiary to items for which the contract provides direct payment.

The Engineer shall measure aggregate bedding for payment as a single unit defined by the number of tons of aggregate bedding supplied, constructed, and accepted. The Engineer reserves the right to limit the quantity for which payment is made to one hundred twenty (120) percent of the contract bid quantity.

The Engineer shall measure removing and relaying sanitary sewer pipe for payment as a single unit defined by the number of linear feet of sewer pipe removed, constructed, and accepted.

The Engineer shall measure sewer pipe for payment as a single unit defined by the number of linear feet of each type and size sewer pipe of supplied, constructed, and accepted. The Engineer shall conduct measurements along the flowline of all sewer pipe from connection to connection for all inlets, manholes, and all other structures. The Engineer shall measure connections to inlets, manholes, and all other structures at the inside face of the structure.

The Engineer shall measure sewer pipe installed by jacking for payment as a single unit defined by the number of linear feet of each type and size of sewer pipe supplied, installed, and accepted. The Engineer shall conduct measurements from connection to connection as identified in the Contract Documents and along the flowline of the pipe unless modified in the field by the Engineer.

The Engineer shall measure sewer pipe installed by boring and jacking for payment as a single unit defined by the number of linear feet of each type and size of sewer pipe supplied, installed, and accepted. The Engineer shall conduct measurements from connection to connection as identified in the Contract Documents and along the flowline of the pipe unless modified in the field by the Engineer.

The Engineer shall measure pipe culverts for payment as a single unit defined as the number of linear feet of each size and type of pipe culvert supplied, constructed, and accepted. The Engineer shall conduct measurements along the centerline of the flowline of the pipe culvert from the start of the pipe culvert to end of pipe culvert excluding any wingwalls or other inlet or outlet structures. Unless otherwise indicated in the Contract Documents, inlet or outlet structures, including wing walls, cut-off walls, etc. will not be measured separately and shall be considered subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure PCC collars for payment as a single unit defined by the number and size of PCC collars constructed and accepted.

The Engineer shall measure PCC cradles for payment as a single unit defined by the number and size of PCC cradles constructed and accepted.

The Engineer shall measure PCC encasement for payment as a single unit defined by the number of linear feet of PCC encasement constructed and accepted.

The Engineer shall measure wye and tee connections for payment as a single unit defined by the number of each type and size of wye or tee connections constructed and accepted.

The Engineer shall measure connections to existing structures for payment as a single unit defined by the number of connections constructed and accepted.

The Engineer shall measure flared-end sections for payment as a single unit defined by the number of each type and size of flared-end sections constructed and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for excavation, trench protection, jacking pit(s), de-watering, pipe bedding, pipe installation, carrier pipe installation, sand fill, end seals, pipe fittings, PCC cradles for service risers, pipe plugs, backfilling, compaction, marking ends of service lines, and clean-up and disposal of excess material; for supplying and installing casing pipe; for all test equipment, pressure gauges, piping connections, bulkheads, pressure regulators, test plugs, water, anchors, braces, and other miscellaneous items; and for all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Aggregate Bedding	Ton
Remove And Relay ___ Sanitary Sewer Pipe	Linear Foot
Construct ___ Sanitary Sewer Pipe, ___	Linear Foot
Jack ___ Sanitary Sewer Pipe, ___	Linear Foot
Bore and Jack ___ Sanitary Sewer Pipe, ___	Linear Foot
___ Pipe Culvert	Linear Foot
Construct ___ PCC Collar	Each
Construct ___ PCC Cradle	Each
Construct ___ PCC Encasement	Linear Foot
Construct ___ Wye Branch	Each
Construct ___ Connection to Existing Structure	Each
Construct ___ Flared End Section	Each

702 – MANHOLES, INLETS, APPURTENANCES, AND SPECIAL STRUCTURES

702.01 Description.

This work includes supplying and installing, constructing, or adjusting manholes, drop manholes, inlets, and special sewer structures complete with covers, steps, fittings, and appurtenances as required by the Contract Documents or as directed by the Engineer. This work includes reconstructing manhole inverts and adjusting manholes, junction boxes, gas valves, water valves, and cleanouts. This work includes supplying and installing internal or external manhole frame seals including sleeves, extensions, wedges, compression bands, and tightening bands. Special structures consist of manholes on sewers exceeding sixty (60) inches in equivalent diameter, special junction structures, metering stations, siphons, and similar structures constructed on the pipeline. Manholes and special structures shall be precast PCC sections, cast-in-place PCC, or brick masonry.

702.02 Material Requirements.

(A) Precast PCC Manholes, Inlets, Appurtenances, and Special Structures.
Precast PCC manholes shall conform to the requirements of ASTM C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.

(B) PCC Masonry Units.
PCC masonry units for manholes shall conform to the requirements of ASTM C139, Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes.

(C) Brick.
Brick for manholes shall conform to the requirements for Grade MS brick as defined by ASTM C32, Standard Specification for Sewer and Manhole Brick (Made From Clay or Shale).

(D) Castings, Rings, Covers, and Steps.
Castings, rings, and covers shall conform to the requirements of ASTM A48, Standard Specification for Gray Iron Castings.

Step castings shall be co-polymer polypropylene plastic coated steps and shall conform to the requirements of ASTM C478, Standard Specification for Precast Reinforced Concrete Manhole Sections. Co-polymer polypropylene plastic shall conform to the requirements of ASTM D4101, Standard Specification for Polypropylene Injection and Extrusion Materials. Deformed reinforcing bars shall have a minimum diameter of one-half (½) inch and shall conform to the requirements for a Grade 60 deformed steel bar as defined by ASTM A615, Standard

Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

Manufacture the castings true to pattern. Component parts shall have a fit satisfactory to the Engineer. The finished metal surface shall be clean and free of surface defects that impair serviceability. Finished metal surfaces containing blow or sand holes or plugged or filled holes are not acceptable. Remove all parting fins and pouring gates before delivery to the project. Frame and covers shall be round. Machine finish the bearing surfaces to allow the cover to rest on the frame with the entire perimeter contacting the frame. Clean and shot blast the finished metal before delivery to the project.

(E) Metal Grates.

Metal grates shall conform to the requirements of ASTM A48, Standard Specification for Gray Iron Castings. Manufacture the castings true to pattern. Component parts shall have a fit satisfactory to the Engineer. The finished metal surface shall be clean and free of surface defects that impair serviceability. Finished metal surfaces containing blow or sand holes or plugged or filled holes are not acceptable. Remove all parting fins and pouring gates before delivery to the project. Clean and shot blast the finished metal before delivery to the project.

(F) Frame Seals and Extensions.

Frame seals shall consist of a flexible internal or external rubber sleeve, extensions, wedge strips, and stainless steel expansion or tightening bands designed to prevent leakage of water into the manhole for a minimum design life of twenty-five (25) years. The frame seal and any extensions or wedge strips shall remain watertight during repeated movement of the frame a minimum of two (2) vertical inches and one (1) horizontal inch throughout the design life.

The flexible rubber sleeves and extensions shall be an extruded or molded high grade rubber compound that conforms to the requirements of ASTM C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals. The rubber compound shall have a minimum tensile strength of one thousand five hundred (1,500) pounds per square inch, a maximum compression set of eighteen (18) percent, and a durometer hardness between forty-three (43) and fifty-three (53). Design internal frame seals and extensions to allow installation in locations where the diameters of the frame and chimney have a maximum difference of twenty (20) percent.

The sleeve for internal frame seals shall be either double-, triple-, or quadruple-pleated and have a minimum wall thickness of three-sixteenths ($^{3}/_{16}$) inches. Double-pleated sleeves shall have a minimum unexpanded vertical height of eight (8) inches. Triple-pleated sleeves shall have a minimum unexpanded vertical height of ten (10) inches.

Quadruple-pleated sleeves shall have a minimum unexpanded vertical height of twelve (12) inches. The top and bottom section of the sleeve shall contain an integrally formed expansion band recess and multiple sealing fins. Sealing fins shall contain teardrop holes, air pockets, or other mechanisms that allow the top and bottom sections of the sleeve to conform to minor surface irregularities. Design the top section of the extension to fit into the bottom band recess of the sleeve under the lower band of the frame seal. The extension top section shall have a minimum thickness of three-thirty-seconds ($^{3}/_{32}$) inches. The remainder of the extension shall have a minimum thickness of three-sixteenths ($^{3}/_{16}$) inches. The bottom section of the extension shall contain an integrally formed expansion band recess and multiple sealing fins matching that of the rubber sleeve. Any splice used to fabricate the sleeve and extension shall be hot vulcanized and have a strength such that the sleeve shall withstand a one hundred eighty (180) degree bend with no visible separation.

Wedge strips shall be an extruded or molded high grade rubber compound that conforms to the requirements of ASTM C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals. Wedge strips shall have a slope differential that provides a vertical band recess surface, fits into the band recess, and has an integral band restraint. Wedge strips shall have a length that covers the entire inside surface of the manhole with the ends butted.

The minimum thickness of the sleeve for external frame seals shall be three-sixteenths ($^{3}/_{16}$) inches. The minimum unexpanded vertical height of the sleeve shall be six (6) inches. Design the top section of the sleeve to contain multiple sealing fins and to extend over and under the base flange of the frame to allow mechanical locking to the frame. The bottom section of the sleeve shall contain an integrally formed compression band recess and multiple sealing fins. The extension shall have a minimum thickness of three-sixteenths ($^{3}/_{16}$) inches. Design the top portion of the extension to have an integrally formed band recess that fits into the center of the bottom band recess of the sleeve. The bottom section of the extension shall contain an integrally formed compression band recess and multiple sealing fins. Any splice used to fabricate the sleeve and extension shall be hot vulcanized and have a strength such that the sleeve shall withstand a one hundred eighty (180) degree bend with no visible separation.

Compression and expansion bands shall conform to the requirements of Type 304, sixteen (16) gauge, stainless steel bands as defined by ASTM A240, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels. The bands shall not contain any welded attachments. Expansion bands shall have a minimum width of one and three-fourths ($1^{3}/_{4}$) inches. Compression bands shall have a minimum width of one (1) inch. All studs and nuts used in the compression mechanism shall

conform to the requirements of ASTM F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs, and ASTM F594, Standard Specification for Stainless Steel Nuts. The minimum adjustment range of the bands shall be two (2) diameter inches. The expansion mechanism shall have sufficient capacity to develop and maintain the pressure necessary for a watertight seal. The bands shall use a positive locking mechanism to maintain such pressure.

(G) Not Used.

(H) External Sealing Wraps.
External sealing wraps shall conform to the requirements for a Type II wrap as defined by ASTM C877, Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections.

(I) Rubber Ring Adjustment Risers.
Rubber adjustment risers shall be manufactured and intended for use as an adjustment for sewer appurtenances. Rubber adjustment risers shall consist of not less than eighty percent (80%) by weight of recycled rubber tires. The diameter and thickness of the rubber adjustment risers shall be as shown on the Contract Documents or as required to properly fit and adjust the casting ring. The sealant and adhesive shall be a polyurethane compound designed for use with PCC and masonry materials.

(J) Joint Mortar, PCC Plaster Coating, and Joint Filler.
Pipe joint mortar shall consist of one (1) part Portland cement and two (2) parts sand. The Portland cement shall conform to the requirements for Cement Type I as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2, and Table 4. The sand shall conform to the requirements of ASTM C 144, Standard Specification for Aggregate for Masonry Mortar.

PCC plaster coating shall consist of two (2) parts Portland cement, one (1) part masonry cement, and six (6) parts sand. Portland cement shall conform to the requirements for Cement Type I as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2, and Table 4. Masonry cement shall conform to the requirements of Type S masonry cement as defined by ASTM C91, Standard Specification for Masonry Cement. Sand shall conform to the requirements of ASTM C144, Standard Specification for Aggregate for Masonry Mortar.

Joint filler shall be cold applied, bitumastic joint filler acceptable to the Engineer.

(K) Mortar.
Mortar shall be a one component, non-shrink, polymer modified Type M mortar meeting the requirements of ASTM C387, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete. The mortar shall be formulated for vertical or overhead use,

shall not promote the corrosion of any steel, and shall not contain any chlorides, gypsum, plasters, iron particles, aluminum powder, or gas-forming agents.

(L) Grout.

Grout shall be a pre-mixed, non-metallic, high strength, non-shrink grout and shall conform to the requirements of ASTM C476, Standard Specification for Grout for Masonry. The minimum compressive strength shall be six thousand (6,000) pounds per square inch at twenty-four (24) hours and nine thousand (9,000) pounds per square inch at twenty-eight (28) day compressive strength.

(M) Aggregate Bedding Material.

Aggregate bedding material shall consist of recycled PCC, crushed limestone, quartzite, or dolomite meeting the requirements for Class 1S coarse aggregate as defined by ASTM C33, Standard Specification for Concrete Aggregates. The aggregate shall classify as a well-graded gravel when classified using ASTM D2487, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System). The maximum amount of material passing a #200 (75 µm) standard sieve shall be eight (8) percent and the nominal maximum size shall be one and one-half (1½) inch unless otherwise specified in the Contract Documents.

(N) Borrow Materials.

Borrow material shall consist of silt (ML), silty clay (CL-ML), or lean clay (CL) materials as determined in accordance with ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes. Borrow material shall be free of debris, vegetation, or organic matter. The Engineer must approve all borrow material in writing before use by the Contractor.

(O) PCC.

PCC shall meet the requirements of ASTM C94, Standard Specification for Ready-Mixed Concrete. PCC shall have a minimum twenty-eight (28) day compressive strength of four thousand (4,000) pounds per square inch unless otherwise indicated by the Contract Documents or directed by the Engineer.

Reinforcing steel shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

(P) Portland Cement for PCC and Flowable Fill.
Portland cement for use with flowable fill or storm sewer manholes, inlets, appurtenances, and special structures shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 2 (Maximum Equivalent Alkalies requirements only) and Table 3.

Portland cement for use with sanitary or combined sewer manholes shall conform to the requirements for Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 2 (Maximum Equivalent Alkalies requirements only) and Table 3.

(Q) Aggregate for PCC and Flowable Fill.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete Aggregates.

(R) Fly Ash for Flowable Fill.
Fly ash shall conform to the requirements of Class C Fly Ash as defined by ASTM C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.

(S) Water for PCC and Flowable Fill.
Water shall conform to the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(T) Admixtures for PCC and Flowable Fill.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. An accredited laboratory shall certify that the admixture meets the requirements of the appropriate ASTM designation. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Add calcium chloride on the project site. Mix the calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the

concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC.

Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(U) Flowable Fill Mix Proportioning and Required Properties.
Prepare and submit a flowable fill mix design that identifies the component materials, the proportion of such materials, the twenty-eight (28) day compressive strength, and the air content. Flowable fill shall have a twenty-eight (28) day compressive strength of seventy-five plus or minus fifty (75±50) pounds per square inch and an air content of ten plus or minus three (10±3) percent. Proportion the materials to produce a mixture with a consistency that flows under a very low head.

(V) PCC Mix Proportioning and Required Properties for Sewer Structures.
Proportion PCC mixtures to meet the requirements of Table 702.01. Do not use fly ash in the PCC mixture. Manufacture the PCC in accordance with ASTM C94, Standard Specification for Ready-Mixed Concrete. "M" designation indicates PCC conforms to requirements for sanitary sewer applications.

Table 702.01
PCC Properties

Mix Type	L6	L65M
Portland Cement Content, lbs. per cubic yard	564 min.	611 min.
Coarse Aggregate, % of Total Aggregate	30±3	30±3
Fine Aggregate, % of Total Aggregate	70±3	70±3
Maximum Water Cement Ratio	0.45	0.45
Minimum 28-Day Compressive Strength, psi	3500	4000
Air Content, %	6.5±1.0	6.5±1.0
Slump, inches	2.5±1.5	2.5±1.5
Concrete Temperature during placement, °F	70±20	70±20

Referenced Test Procedures:

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(W) Curing Materials for PCC.

Curing materials shall be membrane-forming compounds or polyethylene film. Liquid membrane-forming compounds for curing PCC shall conform to the requirements for Type 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

702.03 Construction Requirements.

(A) General.

Unless otherwise indicated in the Contract Documents, install manholes, inlets, and special sewer structures in accordance with the following requirements. The Engineer shall resolve any conflicts. Imprint the name of the Contractor and the year of construction on the top of all inlet tops using a preformed stamp acceptable to the Engineer. The Foreman or Superintendent responsible for and directing any work related to sanitary sewer applications shall be a Licensed Sewer Layer as defined in the Municipal Code of Omaha, Nebraska, Chapter 49, Article XVIII Building and Storm Sewers, Division 2 Sewer Layers.

(B) Excavation.

Using equipment designed for the intended use and acceptable to the Engineer, excavate to the lines, grades, and tolerances required by the Contract Documents or as directed by the Engineer regardless of substances encountered. Do not begin the excavation for structures placed in embankment until completing such embankment to an elevation above or equal to the bottom of the structure.

Protect excavations in accordance with the requirements of 29CFR Part 1926, Safety and Health Regulations for Construction. Provide all sheathing, bracing, piling, and shoring necessary to protect the excavation and all adjacent structures. Any damage to the work or to adjacent structures resulting from excavation or backfilling operations or failure to properly brace adjacent structures or excavation walls will be the Contractor's responsibility. Do not excavate beyond the bottom elevation indicated in the Contract Documents of any footings, walls, floors, etc., of an adjacent structure.

The excavation shall be wide enough to allow thorough tamping of the backfill adjacent to the lower portion of the structure. The minimum width shall be two (2) feet wider than the maximum horizontal width of the structure. Over-excavate a minimum of six (6) additional inches below the lower surface of the structure when encountering a rock ledge at the proposed bottom of the structure. Replace the over-excavated material using crushed rock bedding to eliminate any part of the structure from resting on the rock ledge.

Accomplish excavating in a manner that does not create collected or standing water at any place on the site during construction. De-water in a manner acceptable to the Engineer as necessary.

Over-excavate below the lower surface of the structure when the Engineer determines that the soils encountered will not provide adequate support for the structure. Over-excavate to a width and depth as determined by the Engineer. Do not excavate below the depths indicated. Replace over-excavated material to the established elevation using crushed rock compacted to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). Replace unnecessary over-excavation at no additional cost to the City.

(C) Structure Bedding.

Bedding shall consist of soil bedding, aggregate bedding, or construction of a continuous PCC cradle. Soil bedding shall consist of shaping the bottom of the excavation to match the bottom of the structure. Spread a one (1) to two (2) inch layer of pulverized soil or fine gravel across the bottom of the trench.

Aggregate bedding material shall extend the full width of the excavation and to a height as directed by the structure manufacturer, the Contract Documents, or the Engineer. Place the aggregate bedding material in six (6) inch maximum lifts compacted to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).

(D) Manholes, Appurtenances, and Special Structures Installation.

Install the manholes, appurtenances, and special structures at the locations and elevations indicated in the Contract Documents or as directed by the Engineer. Install external frame seals on all new construction unless otherwise indicated in the Contract Documents. Handle and place the structures, extensions, and pipe in a manner that avoids damaging the structure, extensions, pipe, or bedding material. Before constructing the structures, inspect the structures, adjacent pipe, and extensions for cracks or other defects. Do not support structures using blocks.

Construct manholes using precast PCC sections, or cast-in-place PCC with cast iron frames, covers, and steps. Prevent water and foreign matter from entering the structures, extensions, and adjacent pipe. Take all measures necessary to prevent water from filling the excavation and conduct operations in a manner that prevents pipe flotation. Brace or anchor the structure to prevent displacement after establishing final position. Install external sealing wraps at all joints between precast manhole sections when indicated in the Contract

Documents. Attach steel restraining straps approximately three-fourths (¾) inch from the edge of the external sealing wrap. Enclose the steel restraining straps to prevent contact with the mastic material during tightening.

Clean the interior of all pipe, fittings, and joints before installation. Use lubricants, primers, adhesives, tools, methods, and equipment as recommended by the pipe or joint manufacturer. Cut pipe in a neat workman-like manner using approved methods and equipment as necessary. Smooth cuts by power grinding to remove burrs and sharp edges. Repair any damage to the pipe lining in accordance with the manufacturer's recommendation.

Construct drop connections at the locations indicated in the Contract Documents or as directed by the Engineer. Use pipe, fittings, and connections of the same type as the sewer. Construct stub-outs at the locations indicated in the Contract Documents or as directed by the Engineer. Stub-outs for future connections shall consist of a short length of sewer pipe connected to the wall of the structure. The sewer pipe shall have a spigot and a bell end. Finish the spigot end to be smooth and flush with the inside of the structure wall. Plug stub-outs using a watertight pipe plug acceptable to the Engineer.

Construct manholes, appurtenances, and special structures built on an existing sewer without disrupting service or damaging the sewer. Complete the structure base, walls, and invert before removing the top half of the pipe unless otherwise indicated in the Contract Documents or directed by the Engineer. Cover exposed rough edges of the cut pipe using joint mortar to produce a smooth finish acceptable to the Engineer. Repair or replace any damage to the sewer to the satisfaction of the Engineer at no additional cost to the City.

The maximum vertical joint opening shall be seven-sixteenths ($^{7}/_{16}$) inch. Place joints on the spigot end and lower the bell section on to the spigot end. When using bitumastic-jointing compound, prime each section using solvent material compatible to the adhesive in the mastic. Bitumastic material shall extrude a minimum of seven-sixteenths ($^{7}/_{16}$) inch after jointing. Smooth the extrusion after completing the jointing process. Extrusion is not required when using a flexible preformed butyl rubber or bituminous polymer compounded with modifiers to seal jointed sections.

Set all cover rings to the elevation required by the Contract Documents or as directed by the Engineer. Use masonry units, rubber adjustment risers, or other specialty ring adjustment risers as approved by the Engineer to adjust rings to grade.

(E) Brick and PCC Masonry Unit Manhole Construction.

Thoroughly wet all brick and PCC masonry units immediately before using. Place each unit on a full bed of joint mortar with push joints. Obtain closed joints. The mortar shall fully cover the interfaces of each unit with dense joints. Remove all surplus mortar on the inside face. Rub all inside face mortar joints to produce a smooth finish before the initial set. Joints shall be approximately four-tenths (0.4) inch thick. Lay every seventh (7th) course as stretchers. Lay interweaving courses as headers. Do not construct consecutive layers upon a layer having a defective joint.

Coat the outside face of all brick and PCC masonry unit manholes using PCC plaster coating with a minimum thickness of five-eighths ($^5/_8$) inch. Steel trowel finish the plaster coating to produce a dense, smooth finish. Apply a damp-proof coating consisting of a primer and damp-proofing material to the exterior of all brick and PCC masonry unit manholes from the base to manhole ring. Limit all damp-proofing materials to the treated areas. Do not disfigure untreated portions of the structure with damp-proofing materials. Uniformly apply one coat of primer at the application rate recommended by the manufacturer. Apply two coats of hot asphalt with a mop at the manufacturer's recommended rate. The minimum application rate shall be six (6) gallons per one hundred (100) square feet for horizontal surfaces and five (5) gallons per one hundred (100) square feet for vertical surfaces. The minimum application temperature shall be two hundred fifty (250) degrees Fahrenheit. Perform damp-proofing in dry weather when the ambient temperature is forty (40) degrees Fahrenheit or above. Allow each coating to dry before applying the next coating in accordance with the manufacturer's recommendations. Allow the damp-proofing to cure in accordance with the manufacturer's recommendations before commencing backfilling operations.

Protect all brick and PCC masonry units, joint mortar, and plaster coating from freezing and loss of moisture for a minimum of twenty-four (24) hours after construction using curing materials and methods acceptable to the Engineer. Do not use liquid membrane-forming compounds on any surface to be damp-proofed.

(F) PCC Cast-in-Place Manhole and Inlet Construction.

Construct cast-in-place manholes and inlets at the locations indicated in the Contract Documents or as directed by the Engineer. Construct inlets complete with all rings, covers, frames, and grates.

Forms may be comprised of wood or metal. Wood forms shall be rigid and finished on the PCC side of the form. The rigidity of the forms shall be as needed to resist deformation under the PCC load. Anchor forms as necessary to maintain shape. Support forms to prevent movement of the forms during curing of the PCC. The Engineer

reserves the right to reject structures damaged by movement of the forms.

Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

Provide sufficient lighting for placement and finishing operations as instructed by the Engineer. Do not place PCC at night or in low-light conditions without the Engineer's permission. For colored PCC applications and imprinted applications, prepare a complete test sample of the PCC for approval by the Engineer before commencing construction of the colored or imprinted PCC.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of construction joints to achieve a saturated surface-dry condition immediately before PCC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

For evaporation rates greater than two-tenths pounds per square feet per hour (0.2 lbs/ft^2/hr), take precautions against shrinkage cracking acceptable to the Engineer. Determine the evaporation rate in accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[10]

[10] Figure reprinted with written permission from ACI International.

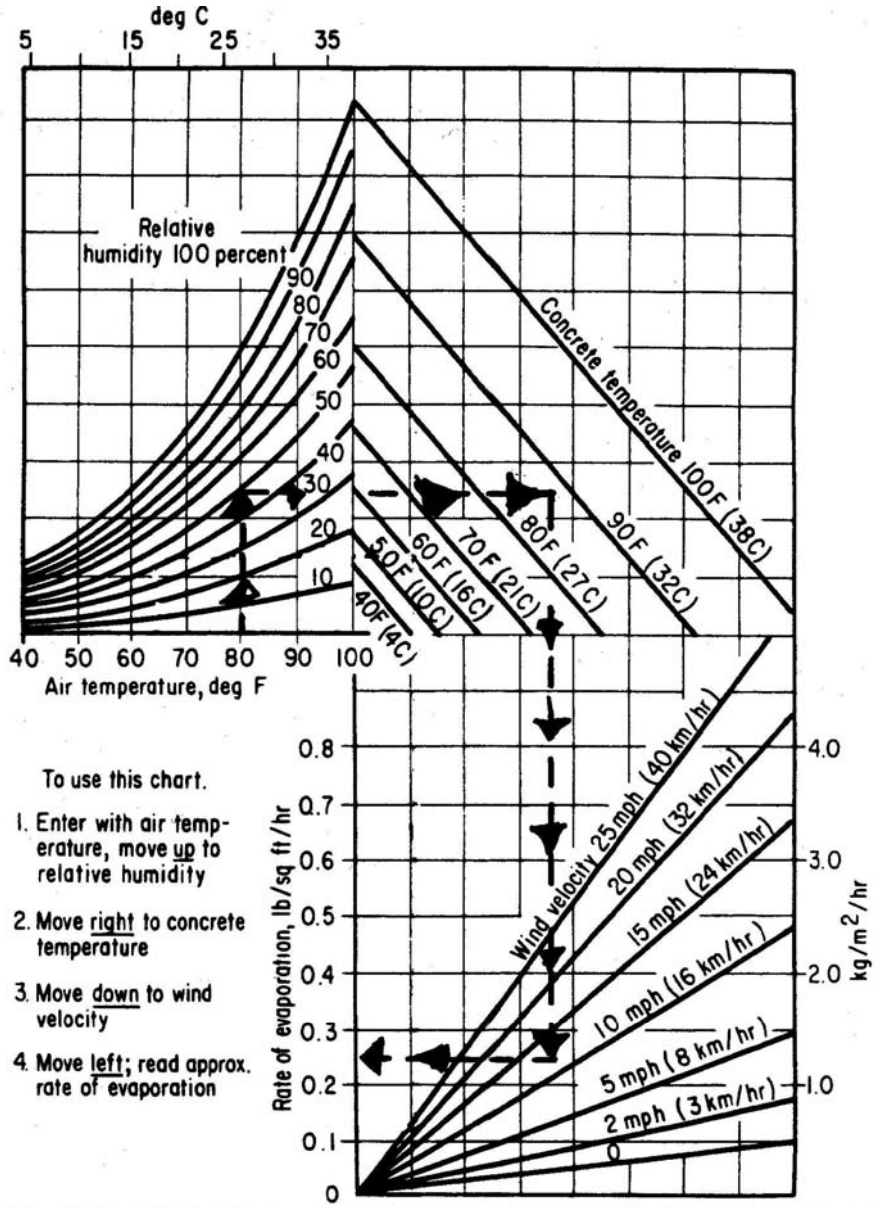

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

During cold weather periods, do not commence PCC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature

falls below forty (40) degrees Fahrenheit. Do not place PCC below the minimum allowable temperature without prior authorization by the Engineer. PCC placement below the minimum temperatures shall include all necessary measures to maintain the temperature of the PCC at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days. Do not place PCC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the PCC in a manner that minimizes segregation.

Use chutes and/or pipes to convey PCC from the mixer or transport vehicle to the forms. Use chutes and pipes comprised of metal or metal lined with plastic, rubber, or other non-deteriorating material acceptable to the Engineer. Equip steep chutes with baffle boards or use short sections that reverse the direction of movement. Extend chutes or pipes inside the forms or through holes left in the form as necessary. Do not allow the PCC to drop a distance greater than five (5) vertical feet. Remove any hardened PCC or other debris before using chutes and pipes. Adjust the chute or pipe discharge ends to facilitate proper PCC placement.

Place the PCC in continuous horizontal layers having a maximum thickness of twenty (20) inches unless otherwise indicated in the Contract Documents or approved by the Engineer. Deposit PCC in each part of the forms as near to the final position as possible.

Consolidate the PCC under and around the reinforcement bars without displacing them. Stop monolithic placements at a vertical bulkhead. Avoid spattering forms or reinforcement bars with PCC when such spattering may harden before incorporation into the mass. Regulate PCC placement to prevent the fluid PCC pressure from exceeding the values used in designing the forms.

Place PCC using pumping equipment as necessary. Use equipment that has sufficient capacity and is acceptable to the Engineer. Do not use components comprised of aluminum or aluminum alloy to convey the PCC. Pumping equipment shall introduce, transport, and discharge the PCC continuously without segregating or introducing air pockets into the material. Do not place the PCC materials used to prime the pumping equipment. Waste such material until the PCC discharged is uniform with the other material in the pumping system as determined by the Engineer. Perform all testing on PCC material after discharging the material from the pumping equipment.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

After placing and before striking off, consolidate PCC using internal vibration provided by one (1) or more tube vibrators. Insert and immediately remove manual vibrators at regular intervals less than three (3) feet apart. Do not drag manual vibrators through the PCC. Use machine-mounted vibrators in accordance with the manufacturer's recommendations. Use a tube vibrator for all formed placements. Place and consolidate each layer before the preceding layer has taken initial set to prevent injury to the fresh PCC and avoid surfaces of separation between layers. Finish all PCC surfaces not contained within the forms in a manner acceptable to the Engineer.

Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC.

Minimize screeding, floating, and troweling operations to avoid overworking or over-manipulation of the PCC. Remove any free water present on the PCC surface between finishing operations in a manner

acceptable to the Engineer. Do not use neat cement or sand-cement mixtures to remove free water. Do not use finishing tools on PCC having free water present on the surface.

Apply an evaporation retardant acceptable to the Engineer to the surface as necessary. Minimize the amount of water added to the PCC surface to aid in finishing. Add water only by misting. Immediately remove excessive amounts of water as determined by the Engineer in a manner acceptable to the Engineer. Do not conduct finishing operations if free water is present on the PCC surface.

Within one (1) hour of PCC placement, protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer.

Upon removal of the forms, fill and seal all holes, honeycombed sections, and joints with joint mortar.

(G) Stub-out Construction.

Construct stub-outs at the elevation and direction indicated in the Contract Documents or directed by the Engineer. Unless otherwise indicated, the minimum length of the stub-out shall be five (5) feet and shall be a type and size of the pipe matching existing pipes connected to the manhole. Support the stub-out section entering the structure using a PCC cradle unless otherwise indicated in the Contract Documents or directed by the Engineer. Cut and grind the stub-out flush with the inside edge of the structure.

(H) Invert Channels.

Align and shape invert channels in accordance with the Contract Documents. Unless otherwise indicated, changes in flow direction shall be smooth, uniform, and made with the largest possible radius. The cross sectional shape of invert channels shall match the lower halves of the entering and exiting pipes. Finish the surface of the channels to produce a dense, smooth surface using a steel trowel.

Structures shall not restrict the flow of sewers. Invert channels for sewer lines that pass through or enter the structure shall be smooth and have a semicircular shape. Invert channels shall consist of a formed structure base, a half pipe installed in the structure base, or sewer pipe constructed through the structure with the top half of the pipe removed. Change the flow direction of pipes using a smooth curve with a maximum radius. Finish manhole floors to be smooth and slope toward the channel. The minimum slope from the floor to the invert channel

shall be eight (8) percent. Extensions shall be precast, pre-fabricated, or shall consist of brick finished with joint mortar. Support pipe entering the structure using a PCC cradle unless otherwise indicated in the Contract Documents or directed by the Engineer. Cut and grind the pipe flush with the inside edge of the structure.

(I) Adjusting Manholes and Inlets.

Remove all surrounding materials from the manhole or inlet as necessary to accomplish the adjustment in a manner acceptable to the Engineer. Saw-cut pavement to a minimum depth of six (6) inches before removing. Set all cover rings or boxes to the elevation required by the Contract Documents or directed by the Engineer. Use masonry units, rubber adjustment risers, or other specialty ring adjustment risers as approved by the Engineer to adjust the manhole or inlet ring to grade. Replace surrounding materials to match the existing condition unless otherwise directed by the Contract Documents or the Engineer.

Payment shall only be made for the vertical adjustment of existing manhole or inlet rings, boxes, or castings. Paid adjustments shall be made for the following conditions: (1) existing street asphalt overlays; or (2) a change in the existing grade elevations.

(J) Wye Branches.

Install wye branches at the locations indicated in the Contract Documents or identified by the Engineer in accordance with the requirements for installation of the adjacent pipe.

(K) Connections to Existing Pipelines and Structures.

Connections to existing pipelines and structures shall be watertight and shall not interfere with the invert channel. Install water stops on all sanitary sewer pipe connections. Connect the pipe to existing structures or pipelines at the locations indicated in the Contract Documents or identified by the Engineer using jointing methods and materials acceptable to the Engineer. Construct connections between jacked pipe and other pipe of different material using a PCC collar. Use adapters and concrete collars at the locations indicated in the Contract Documents or identified by the Engineer. Prepare existing structures by cutting or otherwise constructing an opening with a minimum clearance of two (2) inches on all sides. Position the pipe and fill the opening between pipe and the structure using an expansive grout, rubber gasket, plastic gasket, or other material to provide a watertight seal. Install water stops on all plastic pipe as required by the Engineer. When flowable fill is used, all joints shall have gaskets.

(L) Pipe Cradles, Encasements, and Collars.

Install PCC cradles, total or partial PCC pipe encasements, or PCC collars at the locations identified in the Contract Documents or by the Engineer. Install reinforcing steel as indicated in the Contract Documents. Position and support the pipe using blocks or other

approved methods to maintain position and prevent flotation. Erect forms as necessary. Locate construction joints in the encasement to coincide with the pipe joints. Longitudinal reinforcement shall be continuous through construction joints. Protect and cure the PCC after finishing for a minimum of three (3) days. Do not partially encase flexible pipes without written authorization from the Engineer.

(M) Frame Seal Installation.

All sealing surfaces shall be reasonably smooth and circular, clean and free of any loose material or excessive voids, and uniformly vertical. Using a wire brush or other means acceptable to the Engineer, remove loose or protruding mortar, brick, or other material from the frame, chimney, cone, or corbel that may interfere with the performance of the frame seal, extensions, or wedge. Fill voids flush with the surrounding surface using mortar. Use mortar to construct a uniformly vertical three (3) to four (4) inch wide surface for the sleeve and extensions to seal against as necessary. All surfaces shall conform to the manufacturer's recommendations.

Install external frame seals on newly constructed manholes and frames. Measure each individual manhole and frame before ordering the frame seal to ensure accuracy in ordering. The City is not responsible for under- or over-sized frame seals. Install frame seals upon completion of the construction of the manhole and frame structure. Do not install frame seals when the frame is more than two (2) inches out of alignment with the chimney, cone, or corbel unless otherwise directed by the Engineer. Install frame seals and interlocking extensions in accordance with the manufacturer's instructions using manufacturer recommended equipment and tools. Position the seal and extension(s) tight against the manhole and frame surfaces with the expansion or tightening bands securely locked in-place and extending from the frame down to the top of the chimney, cone, or corbel. Install the seals in a manner that eliminates voids or leakage points along the perimeter. Reinstall or replace any seal that fails to eliminate voids or leakage at no additional cost to the City.

(N) Soil Backfill.

Inspect the pipe and structures before commencing backfilling operations to verify that all pipes and structures are undamaged, in the proper alignment, and have not settled. Remove and relay any pipes that have settled or become damaged or out-of-alignment at no additional cost to the City. Do not backfill PCC encasements or collars until the PCC has a minimum compressive strength of three thousand (3,000) pounds per square inch. Avoid damaging any damp proofing coating, external frame seals, or external sealing wraps during backfilling. Immediately repair any damage to the damp-proof coating without additional cost to the City.

Backfill trenches or pits using soil, granular material, or other materials acceptable to the Engineer. Place and compact the backfill material evenly on each side of the structure and uniformly across the trench or pit. Maintain the same backfill elevation on all sides of the structure at all times. Do not place backfill in a manner that creates unbalanced loading on the structure. Thoroughly compact material under the pipe haunches. Backfill material shall not contain frozen lumps, stones greater than two (2) inches in diameter, chunks of highly plastic clay, or other objectionable material unless approved by the Engineer in writing. Using equipment and methods acceptable to the Engineer, compact the backfill uniformly in lifts not exceeding six (6) inches in compacted thickness without damaging the pipe. The completed backfill shall not yield under repeated loading by heavy trucks or equipment. Construct the embankment to meet the requirements of Table 702.02. The maximum dry density (Standard Effort) and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). The maximum dry density (Modified Effort) and optimum moisture shall be determined by ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

Table 702.02
Backfill Requirements

Depth Below Pavement or Finished Grade	Minimum Compaction Requirement	Acceptable Moisture Range
≤ 1 foot (under pavement and within 4 feet of the edge of pavement and under sidewalk/ bike trail	90% of Maximum Dry Density (Modified Effort)	Optimum Moisture Content –3%, +4%
1-5 feet (all excavation widths)	95% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%
> 5 feet (excavation widths < 6 feet)	92% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +6%
> 5 feet (excavation widths ≥ 6 feet)	95% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%
≤ 1 foot (beyond 4 ft of pavement or beyond edge of sidewalk / bike trail	92% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%

Manipulate, intermix with borrow materials, or replace with borrow materials any existing materials having a moisture content outside the acceptable range.

When directed by the Engineer, import borrow soils or other materials to adjust the moisture content of the existing soil. The cost for extra materials will be paid for as designated in the Contract Documents.

Continue backfilling operations until the top of the backfill is even with the adjacent ground surface. Place topsoil in the upper six (6) inches for locations outside the limits of pavement construction unless otherwise directed by the Engineer. When requested by the Engineer, expose select locations for compaction and moisture content testing. Rework or remove and replace any materials that do not comply with the above requirements as directed by the Engineer.

(O) Flowable Fill Backfill.

The National Ready Mixed Concrete Association must certify the flowable fill production facility. Mixing times shall conform to the requirements of ASTM C94, Specification for Ready-Mixed Concrete. Hand mixing is not allowed. The production facility shall supply a load ticket with the actual batch weights of component materials. Inspect the structure and adjoining pipe before commencing backfilling operations to verify that all pipes are undamaged, in the proper alignment, and have not settled. Before commencing placement of the flowable fill, take all necessary steps to assure that placement of the flowable fill does not damage or displace the structures or adjoining pipe. Repair or reposition structures and remove and relay any pipes that have settled or become damaged or out-of-alignment due to backfilling operations at no additional cost to the City.

Thoroughly mix all water added at the project site in accordance with the recommendations stated in ACI 305, Hot Weather Concreting. Measure all water added to the mix. Do not exceed the water cement ratio stated in the flowable fill mix design approved by the Engineer. Do not add water after discharge of the flowable fill from the mixer has begun.

Place flowable fill within ninety (90) minutes after the addition of cement or fly ash to the mix. The Engineer reserves the right to reduce the allowable time for placement to account for adverse weather conditions or other factors that may accelerate the stiffening of the mix.

(P) Manhole and Junction Structure Acceptance Testing.

Construct all manholes and pipe junction structures to be free from infiltration. Perform acceptance testing for manholes and pipe junction structures consisting of water exfiltration testing or vacuum air testing as required by the Engineer after installation. Use equipment and procedures acceptable to the Engineer. Perform testing on manholes or pipe junction structures only after completing compacted backfill construction around the full structure. Perform testing on manholes and structures prior to construction of pavement, sidewalk, or other structures located above the manholes or structures unless otherwise approved by the Engineer. Notify the Engineer a minimum of twenty-four (24) hours before scheduling testing. Do not perform any acceptance testing without the Engineer present. Repeat testing after locating and correcting any deficient installations at no additional cost

to the City. The Contractor is responsible for any damage to public or private property caused resulting from acceptance testing or by failure of pipe plugs.

Perform hydrostatic exfiltration testing on constructed manholes and pipe junction structures to verify compliance with the values presented in Table 702.03, except where groundwater conditions do not permit proper test head levels to be achieved. The Engineer is responsible for determining when groundwater levels do not permit proper test head levels to be achieved. Perform testing in accordance with the procedures outlined in the City of Omaha Materials Testing Manual.

Table 702.03
Allowable Manhole Leakage Rates
For Manhole Exfiltration Test

Nominal Manhole Diameter feet (m)	Manhole Volume gal./vf (l/vm)	Maximum Leakage Rate gal/vf/hr (l/vm/hr)	Maximum 4-Hr Head Drop inches (mm)*
48 (1.2)	94 (1167)	0.08 (1.0)	0.30 (7.5)
60 (1.5)	147 (1826)	0.10 (1.2)	0.25 (6.2)
72 (1.8)	211 (2620)	0.12 (1.5)	0.20 (5.0)

* At 8 foot (2.4 m) head.

Perform vacuum testing on constructed manholes or pipe junction structures to verify compliance with the values presented in Table 702.04 in accordance with ASTM C1244, Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill. Perform testing in accordance with the procedures outlined in the City of Omaha Materials Testing Manual.

Table 702.04
Minimum Test Times Using Vacuum Testing
For Various Manhole Diameters

Depth Feet (m)	Diameter in Inches (mm)								
	30 (750)	33 (825)	36 (900)	42 (1050)	48 (1200)	54 (1350)	60 (1500)	66 (1650)	72 (1800)
	Time in Seconds								
8 (2.4)	11	12	14	17	20	23	26	29	33
10 (3.0)	14	15	18	21	25	29	33	36	41
12 (3.7)	17	18	21	25	30	35	39	43	49
14 (4.3)	20	21	25	30	35	41	46	51	57
16 (4.9)	22	24	29	34	40	46	52	56	67
18 (5.5)	25	27	32	38	45	52	59	65	73
20 (6.1)	28	30	35	42	50	53	65	72	81
22 (6.7)	31	33	39	46	55	64	72	79	89
24 (7.3)	33	36	42	51	59	64	78	87	97
26 (7.9)	36	39	46	55	64	75	85	94	105
28 (8.5)	39	42	49	59	69	81	91	101	113
30 (9.1)	42	45	53	63	74	87	98	108	121

702.04 Measurement and Payment.

Adjustment of new manholes or inlets is subsidiary to items for which the Contract provides direct payment.

The cost of excavation and over-excavation for installation of the structure; protection of excavations or structures; de-watering; manipulating existing materials or intermixing or manipulation of new materials with the existing soil materials; exposing locations for testing; replacing surrounding materials after adjustment of a manhole or inlet; and performing any or all acceptance testing of the manhole or junction structure is subsidiary to items for which the contract provides direct payment.

The Engineer shall measure manholes for payment as single units defined by the number of vertical feet from the top of the manhole ring to the outlet pipe flowline of each type and size of manhole constructed and accepted. The Engineer shall determine sidewall manhole depth by measuring from the top of the casting to the flowline of pipe less one and five-tenths (1.5) feet. The Engineer shall round measurements to the nearest one-tenth (0.1) foot.

The Engineer shall measure manhole invert reconstruction for payment as a single unit defined as the number of manhole inverts reconstructed and accepted.

The Engineer shall measure manhole adjustments of two (2) inches or less for payment as a single unit defined as the number of manholes adjusted and accepted.

The Engineer shall measure manhole adjustments greater than two (2) inches for additional payment as single units defined as the number additional vertical feet of manholes adjusted and accepted. The Engineer shall round measurements to the nearest inch.

The Engineer shall measure water or gas valve adjustments for payment as single units defined as the number of water or gas valves adjusted and accepted.

The Engineer shall measure cleanout adjustments for payment as single units defined as the number of cleanouts adjusted and accepted.

The Engineer shall measure storm sewer inlets for payment as a single unit defined as the number of each type and size of storm sewer inlet constructed and accepted.

The Engineer shall measure inlet/junction boxes for payment as single units defined as the number of each type of inlet/junction boxes constructed and accepted.

The Engineer shall measure inlet/junction box adjustments for payment as single units defined as the number of inlet/junction boxes adjusted and accepted.

The Engineer shall measure storm sewer inlet repair for payment as a single unit defined as the number of storm sewer inlets repaired and accepted.

The Engineer shall measure storm sewer inlet throat reconstruction for payment as a single unit defined as the number of storm sewer inlet throats reconstructed and accepted.

The Engineer shall measure manhole drop connections for payment as single units defined by number of the vertical feet between pipe flowlines of each type and size of manhole drop connection constructed and accepted. The Engineer shall round measurements to the nearest tenth of a foot.

The Engineer shall measure manhole stub-outs for payment as single units defined by number of each type and size of manhole stub-out constructed and accepted.

The Engineer shall measure internal frame seals, regardless of size, for payment as single units defined by the number of internal frame seals supplied, installed, and accepted.

The Engineer shall measure external frame seals, regardless of size, for payment as single units defined by the number of external frame seals supplied, installed, and accepted. External frame seals installed during new construction are subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure external sealing bands, regardless of size, for payment as single units defined by the number of external sealing bands supplied, installed, and accepted. External sealing bands installed during new construction are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for all saw-cutting, pavement removal, excavation, trench protection, de-watering, PCC bases, PCC cradles, reinforcement, manholes, inlet/junction boxes, grit structures, steps, rings, covers, damp-proofing, masonry, PCC, pipe, fittings, stubs, plugs, cleaning, backfilling, compaction, clean-up and disposal of excess material, pavement patching, and surface restoration; for furnishing and installing frame seals, extensions, wedges, expansion bands, tightening bands, grout, and mortar; for all surface preparation; and for all labor, equipment, tools and incidentals necessary to complete the work.

Description	Unit
Aggregate Bedding	Ton
Construct ___ Manhole	Vertical feet
Reconstruct Manhole Invert	Each
Adjust Manhole, ___	Each
Adjust ___ Valve To Grade	Each
Adjust Cleanout To Grade	Each
Additional Manhole Adjustments	Vertical Feet
Construct ___ Inlet, Type ___	Each
Construct ___ Inlet/Junction Box	Each
Adjust Inlet To Grade	Each
Repair ___ Inlet	Each
Reconstruct Inlet Throats	Each
Construct ___ Diameter Drop Connection	Vertical Feet
Construct ___ Manhole Stub-out	Each
Internal Frame Seal	Each
External Frame Seal	Each
External Sealing Wrap	Each

THIS PAGE INTENTIONALLY LEFT BLANK

703 – PCC-LINED CHANNELS AND FLUMES

703.01 Description.

This work includes constructing PCC-lined channels or flumes, including inlet and outlet end sections along the lines, grades, dimensions, and locations shown indicated in the Contract Documents or as designated by the Engineer.

703.02 Material Requirements.

(A) Portland Cement.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2, and Table 4.

(B) Water.
All water used in the concrete mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(C) Aggregate.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete Aggregates.

(D) Admixtures.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Pozzolanic admixtures shall be fly ash or raw or calcined natural pozzolans meeting the requirements of ASTM C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete. An accredited laboratory shall certify that the admixture meets the requirements of the appropriate ASTM designation. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Add calcium chloride on the project site. Mix the calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the

concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC.

Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(E) PCC Mix Proportioning.

Proportion PCC mixtures to meet the requirements of Table 703.01.

Table 703.01
Concrete Properties

Mix Type	L6AE
Portland Cement Content, lbs. per cubic yard	564±47
Coarse Aggregate, % of Total Aggregate	30±3
Fine Aggregate, % of Total Aggregate	70±3
Maximum Water Cement Ratio	0.45
Minimum 28-Day Compressive Strength, psi	3500
Entrained Air Content, %	6.0±1.5
Slump, inches	1.5±1.5
Concrete Temperature during placement, °F	70±25

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(F) Reinforcing Steel.

Reinforcing steel shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

(G) Curing Materials.

Curing materials shall be membrane-forming compounds or polyethylene film. Liquid membrane-forming compounds for curing PCC shall conform to the requirements for Type 2, Class B as defined

by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

703.03 Construction Requirements.

(A) Equipment.

The National Ready Mixed Concrete Association shall certify that the production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

Spread the PCC uniformly and without segregation. Use a paving machine or a hand operated or non-self-propelled screeds to strike off the PCC. Protect adjacent materials and structures from paving machine tracks using cushions comprised of rubber or wood. Operate the paving machine at a steady pace that conforms to the manufacturer's recommendations and provides a satisfactory finish.

Vibrators shall be internal, tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times. Use an internal tube vibrator whenever a vibrating screed is used.

Joint cutting saws shall use a water-cooled, diamond-tipped blade. Saws shall have an adjustable guide pointer. Keep a minimum of two (2) operational saws on-site at all times.

Joint sealant applicators shall consist of a double-walled melting pot with a mechanical agitator that continuously stirs the material. The heating unit shall not apply direct heat to the sealant material. Applicators shall use a pressurized system for placing the material. Applicators shall have flow controls that allow the operator to control the flow of the heated material. Use an applicator nozzle that fills the joint from the bottom to the top.

Keep a sufficient number of ten (10) foot straightedges and a six (6) inch steel channel master straightedge with a minimum length of ten (10) feet on site at all times.

(B) Forms.

Forms shall be rigid, straight metal. The maximum deflection of forms shall not exceed one-eighth ($^1/_8$) inch in ten (10) feet when tested as a simple beam and subjected to a center load of one thousand seven hundred (1,700) pounds. Clean and oil forms before PCC placement.

The minimum length shall be ten (10) feet. The depth shall be equivalent to the design thickness at the edge of the PCC. Bolt additional forms to the top of a form as necessary to achieve additional depth. Use a minimum of three (3) anchors for each individual form.

Radius forms may be comprised of wood or metal. Wood radius forms shall be rigid and finished on the PCC side of the form. The rigidity of the radius forms shall be as needed to resist deformation under the concrete load. Anchor radius forms as necessary to maintain the shape of the radius.

Bed and join forms neatly and tightly to line and grade in a manner that resists movement. Do not place forms on pedestals to maintain proper grade. Remove and reset forms that vary more than one-eighth ($^1/_8$) inch in ten (10) feet from line or grade.

Use the edge of existing PCC as a form as necessary provided the existing PCC has a smooth vertical face or a keyed face that is free of soil or other contaminants.

(C) Placing Reinforcing Steel.

Place steel reinforcement as directed by the Contract Documents. Overlap adjacent sheets of wire fabric or bar mats a minimum of twelve (12) inches. Keep sheets and mats straight during and after installation. Tie lapped sheets using steel wire or other material acceptable to the Engineer. Tie longitudinal laps at a spacing of twenty-four (24) inches or less. Tie transverse laps at a spacing of sixty (60) inches or less.

Place the reinforcement a maximum of three (3) inches from a longitudinal construction joint and a maximum of two (2) inches from a transverse construction joint. Place the reinforcement within one-fourth (¼) inch of the elevation required in the Contract Documents. Position the reinforcement before placing the concrete. Use metal supports acceptable to the Engineer to maintain the position of the reinforcement. Do not place any load on positioned reinforcement that causes the reinforcement to move out of position. The Contractor is responsible for maintaining the position of the reinforcement.

Place reinforcement mechanically using equipment designed and intended for this purpose and approved by the Engineer. Mechanically placed reinforcement is subject to the positioning requirements for manually placed reinforcement.

Uniformly lubricate one-half (½) of the length of any dowel bars using a petroleum-based oil or grease. Coat the bar with a maximum coating thickness of one-thirty second ($^1/_{32}$) inch. The lubricant coloring shall contrast with the coloring of the non-lubricated dowel bar.

(D) PCC Footings.

Excavate trenches along the footing outline and to the elevation indicated in the Contract Documents or established by the Engineer. Do not round or undercut footing corners or edges. Smooth the trench bottom to conform to the lines, grades, and dimensions of the footing. The Engineer reserves the right to alter the bottom elevation of footings as necessary to satisfy changes in dimensions or footing elevations or to place the footing on satisfactory soils.

When trench excavations encounter a solid rock bottom, expose and prepare the solid rock in horizontal or properly serrated beds for receiving masonry as allowed by the Engineer. Clean and grout seams or crevices. Remove loose or disintegrated rock and thin strata. De-water the trench when encountering a water-bearing stratum. De-water the trench to an elevation below the elevation of the footing by draining, pumping, bailing, or other methods approved by the Engineer. Maintain the trench as dry as possible or practicable during the placing and hardening of the concrete.

Excavate the trench to the width and depth designated by the Engineer when the trench bottom contains soft, unstable, saturated soils or conditions that prohibit the proper PCC placement within a reasonable time after performing proper de-watering activities. Backfill the area with porous, granular material acceptable to the Engineer to the footing elevation indicated in the Contract Documents or established by the Engineer. Maintain the water level at an elevation lower than the top of the porous, granular material until completing the footing and channel or flume construction.

Construct PCC footings directly in excavated trenches without the use of forms unless otherwise directed by the Contract Documents or the Engineer. Place footings monolithically with the paved channel or flume. Backfill over-excavated trenches using PCC placed monolithically with the footing at no additional cost to the City.

(E) Placing PCC.

Provide sufficient lighting for placement and finishing operations as instructed by the Engineer. Do not place PCC at night or in low-light conditions without the Engineer's permission. For colored PCC applications and imprinted applications, prepare a complete test sample of the PCC for approval by the Engineer before commencing construction of the colored or imprinted PCC.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of construction joints to achieve a saturated surface-dry condition immediately before PCC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

For evaporation rates greater than two-tenths pounds per square feet per hour (0.2 $lbs/ft^2/hr$), take precautions against shrinkage cracking acceptable to the Engineer. Determine the evaporation rate in accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[11]

[11] Figure reprinted with written permission from ACI International.

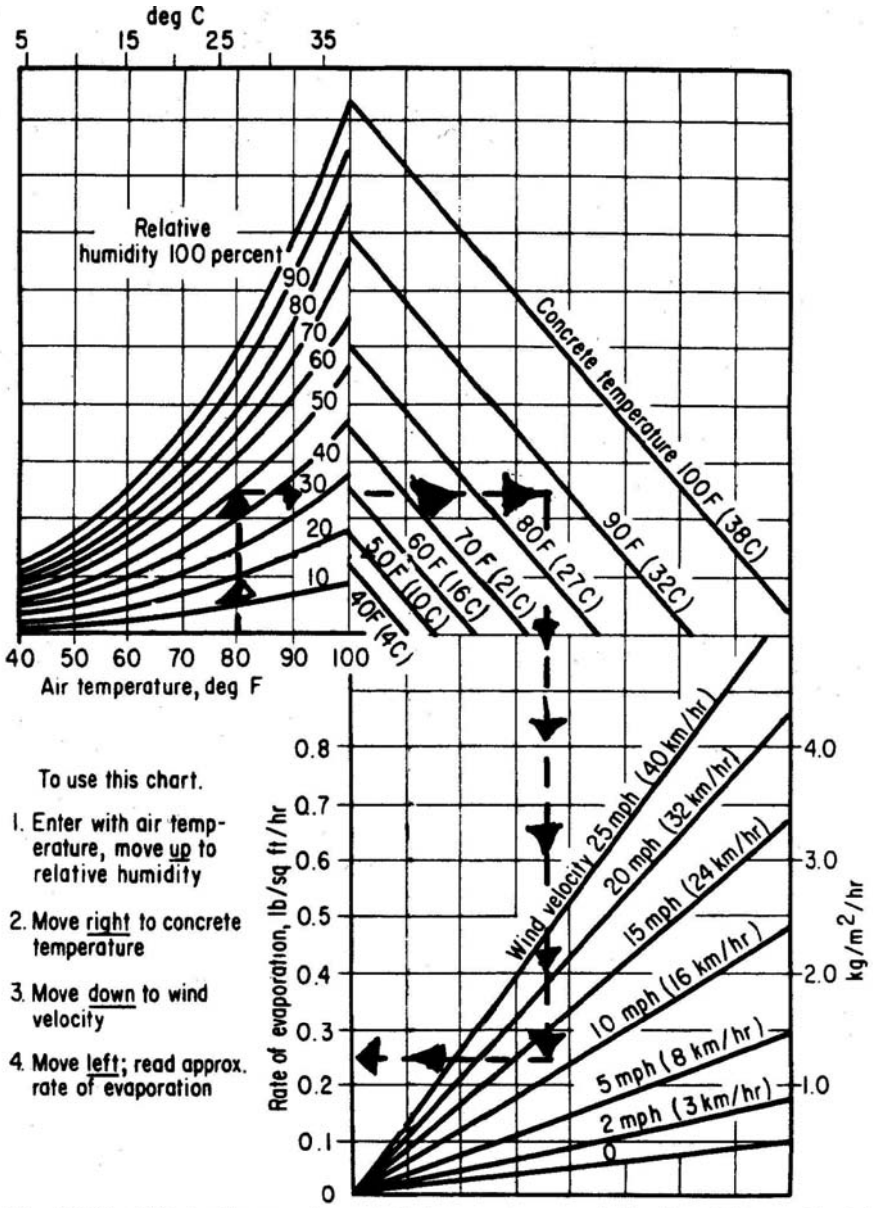

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

During cold weather periods, do not commence PCC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature

falls below forty (40) degrees Fahrenheit. Do not place PCC below the minimum allowable temperature without prior authorization by the Engineer. PCC placement below the minimum temperatures shall include all necessary measures to maintain the temperature of the PCC at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days. Do not place PCC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the PCC in a manner that minimizes segregation.

Use chutes and/or pipes to convey PCC from the mixer or transport vehicle to the forms. Use chutes and pipes comprised of metal or metal lined with plastic, rubber, or other non-deteriorating material acceptable to the Engineer. Equip steep chutes with baffle boards or use short sections that reverse the direction of movement. Extend chutes or pipes inside the forms or through holes left in the form as necessary. Do not allow the PCC to drop a distance greater than five (5) vertical feet. Remove any hardened PCC or other debris before using chutes and pipes. Adjust the chute or pipe discharge ends to facilitate proper PCC placement.

Place the PCC in continuous horizontal layers having a maximum thickness of twenty (20) inches unless otherwise indicated in the Contract Documents or approved by the Engineer. Deposit PCC in each part of the forms as near to the final position as possible.

Consolidate the PCC under and around the reinforcement bars without displacing them. Stop monolithic placements at a vertical bulkhead. Avoid spattering forms or reinforcement bars with PCC when such spattering may harden before incorporation into the mass. Regulate PCC placement to prevent the fluid PCC pressure from exceeding the values used in designing the forms.

Place PCC using pumping equipment as necessary. Use equipment that has sufficient capacity and is acceptable to the Engineer. Do not use components comprised of aluminum or aluminum alloy to convey the PCC. Pumping equipment shall introduce, transport, and discharge the PCC continuously without segregating or introducing air pockets into the material. Do not place the PCC materials used to prime the pumping equipment. Waste such material until the PCC discharged is uniform with the other material in the pumping system as determined by the Engineer. Perform all testing on PCC material after discharging the material from the pumping equipment.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

After placing and before striking off, consolidate PCC using internal vibration provided by one (1) or more tube vibrators. Insert and immediately remove manual vibrators at regular intervals less than three (3) feet apart. Do not drag manual vibrators through the PCC. Use machine-mounted vibrators in accordance with the manufacturer's recommendations. Use a tube vibrator for all formed placements. Place and consolidate each layer before the preceding layer has taken initial set to prevent injury to the fresh PCC and avoid surfaces of separation between layers. Finish all PCC surfaces not contained within the forms in a manner acceptable to the Engineer.

Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC.

Minimize screeding, floating, and troweling operations to avoid overworking or over-manipulation of the PCC. Remove any free water present on the PCC surface between finishing operations in a manner

acceptable to the Engineer. Do not use neat cement or sand-cement mixtures to remove free water. Do not use finishing tools on PCC having free water present on the surface.

Apply an evaporation retardant acceptable to the Engineer to the surface as necessary. Minimize the amount of water added to the PCC surface to aid in finishing. Add water only by misting. Immediately remove excessive amounts of water as determined by the Engineer in a manner acceptable to the Engineer. Do not conduct finishing operations if free water is present on the PCC surface.

Within one (1) hour of PCC placement, protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer.

(F) Contraction Joints.

Saw longitudinal and transverse contraction joints at the dimensions and intervals indicated in the Contract Documents. Sawing shall begin as soon as the PCC has sufficiently hardened to allow sawing without tearing or raveling. Use a straight, chalked line or other reference acceptable to the Engineer for guiding the line of the saw. Continue all saw-cuts through any new PCC slopes attached to the PCC. Sequence the sawing to prevent random cracking. Route random cracks to a minimum depth of one (1) inch and a maximum width of three-eighths (3/8) inch. Seal or apply curing compound to all contraction joints or routed cracks within twenty-four (24) hours of sawing or routing. Clean the contraction joints and routed cracks immediately before sealing operations. Place joint sealant in the sawed contraction joints and routed cracks to one-fourth (¼) inch below the PCC surface.

(G) Construction Joints.

Construct longitudinal and transverse construction joints to the dimensions indicated in the Contract Documents. Clean the construction joint immediately before sealing operations. Place joint sealant in the construction joint to one-fourth (¼) inch below the PCC surface.

(H) Requirements for Thickness.

When required by the Engineer, check the thickness of the PCC by coring in accordance with ASTM C174, Standard Test Method for Measuring the Thickness of Concrete Elements Using Drilled Concrete Cores. Divide the PCC into sections of six thousand (6,000) square feet or less for coring. Take a minimum of two cores from each section

at locations selected by the Engineer. Deliver the cores to the Engineer for measurement.

703.04 Measurement and Payment.

The cost of excavation and over-excavation including additional footing excavation, for installation of the structure; protection of the excavation or structures; and de-watering is subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure PCC-lined channels for payment as a single unit defined as the number of linear feet of PCC-lined channel constructed and accepted.

The Engineer shall measure PCC-lined flumes for payment as a single unit defined as the number of linear feet of PCC-lined flume constructed and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for preparing the subgrade, excavation and backfilling; for furnishing and placing concrete, reinforcing steel, and welded steel wire fabric, including the footings and inlet and outlet sections; for all materials, forms, disposal of surplus excavated material; and for all labor, equipment, tools and incidentals necessary to complete the work.

Description	Unit
PCC-Lined Channel	Linear Foot
PCC-Lined Flume	Linear Foot

THIS PAGE INTENTIONALLY LEFT BLANK

704 – WATER SERVICE FACILITIES

704.01 Description.

This work includes relocating curb stops and boxes, removing and relocating water meters and water meter manholes, lowering existing water service piping, and replacing existing lead water service lines with new copper pipe.

704.02 Material Requirements.

Copper pipe shall be type K copper tubing as defined by ASTM B698, Standard Classification for Seamless Copper and Copper Alloy Plumbing Pipe and Tube. The diameter of the pipe shall match the existing pipe. The minimum diameter shall be three-fourths (¾) inch. Water main taps and transition fittings shall comply with the requirements of the Metropolitan Utilities District rules and regulations.

704.03 Construction Requirements.

(A) General.

A licensed plumber or workers under the direct supervision of a licensed plumber shall perform all work related to relocating curb stops and boxes, removing and relocating water meters and water meter manholes, lowering existing water service piping, and replacing existing lead water service lines with new copper pipe. Comply with all applicable requirements of the City of Omaha Plumbing Code and MUD (Metropolitan Utilities District) Water Rules and Regulations regarding the installation, removal, or relocation of water service facilities. Obtain all necessary permits as required. Coordinate operations with utility companies to minimize interference with the removal, replacement, abandonment, or relocation of the underground and overhead utility operations. Maintain access to all fire hydrants at all times unless otherwise indicated in the Contract Documents or approved in writing by the Engineer. Do not store or stockpile materials within fifteen (15) feet of any fire hydrant.

Locate all utilities, sprinkler systems, or other underground services before commencing the work. The City is not responsible for any costs incurred due to damaged or destroyed utilities, sprinkler systems, or other underground services. All utilities shall remain in service unless otherwise indicated in the Contract Documents. Do not commence the work until making all necessary arrangements to protect known utilities. Notify the Engineer, the utility, and the property owner in the event of an interruption of water or utility services. Coordinate with repair operations to restore the service as soon as possible. In no case shall interruption to water service be allowed to exist for more than twenty-four (24) hours.

(B) Excavation.

Excavate to the lines, grades, and tolerances required by the Contract Documents or as directed by the Engineer using equipment designed for the intended use and acceptable to the Engineer. Do not begin the excavation for water service facilities or related structures placed in embankment until completing such embankment to an elevation above or equal to the bottom of the structure.

Protect excavations in accordance with the requirements of 29CFR Part 1926, Safety and Health Regulations for Construction. Provide all sheathing, bracing, piling, and shoring necessary to protect the excavation and all adjacent structures. Any damage to the work or to adjacent structures resulting from failure of excavation walls, will be the Contractor's responsibility. Do not excavate beyond the bottom elevation indicated in the Contract Documents of any footings, walls, floors, etc., of an adjacent structure without written approval from the Engineer. Do not protect excavations by sloping without written permission from the Engineer.

The excavation shall be wide enough to allow thorough tamping of the backfill adjacent to the lower portion of the water service facility or related structure. The minimum width shall be two (2) feet wider than the maximum horizontal width of the water service facility or related structure. Over-excavate any unsuitable material as directed by the Engineer. Replace the over-excavated material using crushed rock bedding.

Accomplish excavating in a manner that does not create collected or standing water at any place on the site during construction. De-water in a manner acceptable to the Engineer as necessary.

Over-excavate below the lower surface of the water service facility or related structure when the Engineer determines that the soils encountered will not provide adequate support for the structure. Over-excavate to a width and depth as determined by the Engineer. Do not excavate below the depths indicated. Replace over-excavated material to the established elevation using crushed rock compacted to a minimum of one hundred (100) percent of the maximum density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). Replace unnecessary over-excavation at no additional cost to the City.

(C) Water Meters and Water Meter Manholes.

Remove and relocate water meters presently located in water meter pits indicated in the Contract Documents or as directed by the Engineer. Do not perform any relocation work without prior approval of the Metropolitan Utilities District. Perform relocation work in accordance with the Metropolitan Utilities District rules and regulations. Relocate

to a location approved by the Engineer within the building to be served. Metropolitan Utilities District reserves the right to replace the removed meter before reinstallation in the new location. Construct a new water meter manhole at the new location in accordance with the requirements of the Metropolitan Utilities District rules and regulations.

Reroute existing service lines around the existing water meter manhole to the new water meter location and connect to the water meter. Use copper pipe for water line extensions between the existing water meter manhole and the new water meter location. Route the copper pipe extension along the shortest practicable distance acceptable to the Engineer between the existing water meter manhole and the new water meter location. Remove and dispose of the existing water meter manhole after extending the service lines.

(D) Curb Stops and Curb Boxes.

Existing curb stops shall remain in place unless otherwise indicated in the Contract Documents or directed by the Engineer. Install new curb stops in the water service line a minimum of twelve (12) inches behind the proposed curb line unless otherwise indicated in the Contract Documents or directed by the Engineer. Do not replace existing copper service lines in good condition between the existing corporation stop and the new curb stop. Replace all existing service lines in poor condition or constructed of unsuitable material using copper pipe unless otherwise indicated in the Contract Documents or directed by the Engineer. Relocate and adjust to finish grade existing curb boxes over new curb stops. Replace curb boxes that the Engineer deems unsuitable for relocation.

(E) Service Pipe Replacement.

Replace water service pipe at locations indicated in the Contract Documents or as directed by the Engineer using new copper pipe in accordance with the rules and regulations of the Metropolitan Utilities District. Replace all lead water service pipe and curb stops from the corporation stop at the main to the existing curb stops or water meter manhole using copper pipe and new curb stops acceptable to the Engineer. Match the existing pipe diameter unless the pipe diameter is less than three-fourths (¾) inch. Install three-fourths (¾) inch diameter pipe in place of existing pipe less than three-fourths (¾) inch in diameter. Replace existing pipe greater than two (2) inches in diameter as directed by the Engineer.

(F) Water Main Tap Construction.

Construct water main taps in accordance with the requirements of the Metropolitan Utilities District rules and regulations.

(G) Transition Fittings Installation.

Install transition fitting in accordance with the manufacturer's recommendations and the requirements of the Metropolitan Utilities District rules and regulations. The Engineer shall resolve any conflicts.

(H) Backfill.

Inspect the water service facility or related structure before commencing backfilling operations to verify that all items are undamaged and in the proper alignment. Remove and relay any items that have become damaged or out-of-alignment at no additional cost to the City.

Backfill trenches or pits using soil, granular material, or other materials acceptable to the Engineer. Place the backfill material evenly on each side of the water service facility or related structure and uniformly across the trench or pit. Thoroughly compact material under the water service facility haunches. Backfill material shall not contain frozen lumps, stones greater than two (2) inches in diameter, chunks of highly plastic clay, or other objectionable material unless approved by the Engineer in writing. Compact the backfill uniformly in lifts not exceeding six (6) inches in compacted thickness without damaging the pipe using equipment and methods acceptable to the Engineer. The completed backfill shall not yield under repeated loading by heavy trucks or equipment. Construct the embankment to meet the requirements of Table 706.01. The maximum dry density (Standard Effort) and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)). The maximum dry density (Modified Effort) and optimum moisture shall be determined by ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

Table 704.01
Backfill Requirements

Depth Below Pavement or Finished Grade	Minimum Compaction Requirement	Acceptable Moisture Range
≤ 1 foot (under pavement and within 4 feet of the edge of pavement and under sidewalk/ bike trail	90% of Maximum Dry Density (Modified Effort)	Optimum Moisture Content –3%, +4%
1-5 feet (all excavation widths)	95% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%
> 5 feet (excavation widths < 6 feet)	92% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +6%
> 5 feet (excavation widths ≥ 6 feet)	95% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%
≤ 1 foot (beyond 4 ft of pavement or beyond edge of sidewalk / bike trail	92% of Maximum Dry Density (Standard Effort)	Optimum Moisture Content –3%, +4%

Manipulate, intermix with soil materials, or replace with borrow materials any existing materials having a moisture content outside the acceptable range.

When directed by the Engineer, import borrow soils or other materials to adjust the moisture content of the existing soil. The cost for extra materials will be paid for as designated in the Contract Documents.

Continue backfilling operations until the top of the backfill is even with the adjacent ground surface. Place topsoil in the upper six (6) inches for locations outside the limits of pavement construction unless otherwise directed by the Engineer. When requested by the Engineer, expose select locations for compaction and moisture content testing. Rework or remove and replace any materials that do not comply with the above requirements as directed by the Engineer.

704.04 Measurement and Payment.

The cost of excavation and over-excavation for installation of the structure; protection of the excavation or structures; de-watering; providing openings in basements, walls, or access within buildings to the new location and water meter supports; relocating existing curb boxes; transition fittings; replacement of a removed meter by the utility company; manipulating existing materials, intermixing with borrow materials; or intermixing or manipulation of new materials with the existing soil materials; and exposing locations for testing is subsidiary to items for which the contract provides direct payment.

The Engineer shall measure water meters and water meter manhole relocation for payment as a single unit defined by the number of water meter and water meter manhole combinations removed, relocated, and accepted.

The Engineer shall measure installation of curb stop and curb box combinations for payment as a single unit defined by the number of curb stop and curb box combinations supplied, installed, and accepted.

The Engineer shall measure installation of copper pipe for payment as a single unit defined by the number of linear feet of copper pipe supplied, installed, and accepted. The Engineer shall measure linear feet in the horizontal direction only.

The Engineer shall measure construction of a water main tap for payment as a single unit defined by the number of water main taps supplied, constructed, and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for all excavation, backfilling, and pavement repair; and for furnishing all fittings, materials, labor, equipment, tools and incidentals necessary to complete the work.

Description	**Unit**
Relocate Water Meter and Water Meter Manhole	Each
Install Curb Stop and Curb Box	Each
Install Copper Pipe	Linear Foot
Construct ___" Water Main Tap	Each

705 – VIDEO SEWER INSPECTION

705.01 Description.

This work includes video inspection of the interior of sewer systems having an inside diameter of eight (8) inches or greater.

705.02 Material Requirements.

None.

705.03 Construction Requirements.

Provide the Engineer a minimum of twenty-four (24) hours notice before scheduling a video inspection. An independent sewer inspection service acceptable to the Engineer shall perform all video inspections. Accomplish video inspection using a closed-circuit television surveying system. The camera shall have built-in lights, three hundred sixty (360) degree pan, tilt, remote focus, and auto-iris functions. Lighting shall move with the camera head, be appropriate for the pipe diameter & material type, and provide sufficient illumination to clearly see along the pipe length.

Do not commence the video inspection without the Engineer present. Repair all identified defects in new sewer systems in a manner acceptable to the Engineer at no additional cost to the City. An independent sewer inspection service shall re-inspect any repair work resulting from any identified defects at no additional cost to the City.

Thoroughly clean and remove all excess mortar, joint sealant, earth, and all other debris from the pipe before inspection. Do not perform inspections until all backfilling activities are completed unless otherwise required by the Contract Documents or directed by the Engineer. Perform inspections before construction of pavement, sidewalk, or other structures located above the pipe unless otherwise approved by the Engineer. Do not inspect the pipe during periods of water flowing through the pipe unless approved by the Engineer.

Furnish a written report and continuous video to the Engineer. The written report shall contain the location and position of all service connections, a written summary of the apparent condition and alignment of the sewer, and indexed pictures of all misalignments, cracks, offset joints, faulty gaskets, obstructions, breaks, exposed filler material, and water infiltration points. The continuous video shall be on a VHS videotape or other format acceptable to the Engineer and shall contain the entire sewer line with locations superimposed on the video.

705.04 Measurement and Payment.

The Engineer shall measure video inspections as a single unit defined as the number of linear feet of sewer inspected, reported, and accepted. The Engineer shall measure along the bottom of the sewer system from manhole centerline to manhole centerline. The Engineer shall measure each linear foot for payment only once. Overlap in inspections due to construction phasing, access, or other causes will not be measured for payment, unless otherwise indicated in the Contract Documents.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for all labor, equipment, tools and incidentals necessary to complete the work.

Description	Unit
Perform Television Inspection	Linear Foot

800 ROADSIDE IMPROVEMENT AND EROSION CONTROL

801 – TOPSOIL

801.01 Description.

This work includes the removal of topsoil from cut areas or areas to be covered by embankments in such quantity as required to cover the slopes, ditches, and shoulders in accordance with the details shown in the plans; loading, hauling, stockpiling if necessary; and the subsequent placing, spreading and finishing of the topsoil material in accordance with these specifications.

801.02 Material Requirements.

Topsoil material shall be loam, sandy loam, silty clay loam, or clay loam humus-bearing soils. Imported topsoil shall meet the requirements of ASTM D5268, Standard Specification for Topsoil Used for Landscaping Purposes. The Contractor shall reuse topsoil removed and stockpiled on the project unless otherwise indicated in the Contract Documents or authorized by the Engineer.

801.03 Construction Requirements.

Complete clearing and grubbing operations before removing the topsoil. Unless otherwise indicated in the Contract Documents, such clearing and grubbing is subsidiary to items for which the Contract provides direct payment. Install all appropriate sediment controls before beginning salvage operation in accordance with the Contract Documents. Remove topsoil in a manner acceptable to the Engineer that avoids incorporating any appreciable quantities of subsoil or other foreign materials with the topsoil. Remove topsoil to the depth indicated in the Contract Documents or as directed by the Engineer.

Salvage and stockpile topsoil in a location acceptable to the Engineer before beginning earthwork operations. Topsoil stockpiles in the Right-of-Way shall not interfere with natural drainage or cause off-site sediment damage. The Contractor shall limit stockpile side slopes to a ratio of 1V:3H. Immediately upon completion of daily stockpiling activities, the Contractor shall surround all topsoil stockpiles with sediment controls. The Contractor may enter agreements with adjacent landowners, or other persons for areas to stockpile the topsoil material. Such agreements shall remain separate from the Contract.

Place topsoil during conditions favorable for grading, sodding, or seeding. Before placing topsoil, scarify areas receiving topsoil to a minimum depth of two (2) inches. Place topsoil evenly to a lightly compacted depth of at least four (4) inches. Remove large clods that will not break down, rocks,

twigs, and other foreign material. Dress the entire surface to present a uniform appearance. Add water as necessary to facilitate shaping. The finished work shall conform to the lines, grades, slopes, and typical cross sections indicated in the Contract Documents. Correct surface irregularities to prevent the formation of depressions or water pockets. Compact topsoil lightly to ensure contact with the underlying soil and to create a uniform seedbed.

Dispose of any excess topsoil removed from the project in a manner acceptable to the Engineer. Such removal is subsidiary to items for which the Contract provides direct payment.

801.04 Measurement and Payment.

The Engineer shall measure topsoil removal for payment as a single unit defined as the number of square yards of topsoil removed, stockpiled, and accepted.

The Engineer shall measure topsoil placement for payment as a single unit defined as the number of square yards of topsoil placed and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for all excavating, loading and hauling, stockpiling and reclaiming the material; for furnishing- and applying water; for disposing of excess material; and for all labor, equipment, tools and incidentals necessary to complete the work.

Description	Unit
Topsoil Removal	Square Yard
Topsoil Placement	Square Yard

802 – SEEDING

802.01 Description.

This work includes furnishing and placing seed, fertilizer, and mulch in accordance with the Contract Documents or as designated by the Engineer. Perform lawn and turf seeding in all yard, park, golf course, or other similar areas. Perform hydraulic seeding on all slopes steeper than 1V:3H. Perform Type A seeding work in median areas and areas twelve (12) feet or wider and adjacent to pavement, surfaced shoulders, or curb. Perform Type B seeding on all other areas.

802.02 Material Requirements.

(A) General.
All seed origins shall be State of Nebraska or adjoining states unless otherwise approved by the Engineer in writing. Submit a seed tag to the Engineer representing the seed that clearly illustrates the variety, origin, and analysis of the seed for any proposed substitute variety or origin. The Engineer reserves the right to reject substitute varieties or origins for any reason. All seeds must comply with applicable local, state, and federal seed laws. Furnish a certified laboratory analysis of each type and lot of seed proposed for use before delivery to the project. The certified laboratory analysis shall provide all information required by local, state, and federal seed laws.

(B) Non-irrigated Lawn and Turf Seed.
Non-irrigated lawn and turf seed shall be Interagency Bluetag Certified and shall have a minimum germination of ninety (90) percent and a purity of ninety-eight (98) percent. Proportion the seed in accordance with Table 802.01.

Table 802.01
Non-irrigated Lawn and Turf Seed

Seed Type	Blend Percentage
Tall Fescue	90
Perennial Rye Grass	10

(C) Irrigated Lawn and Turf Seed.
Irrigated lawn and turf seed shall be Interagency Bluetag Certified and shall have a minimum germination of ninety (90) percent and a purity of ninety-eight (98) percent. Proportion the seed in accordance with Table 802.02.

Table 802.02
Irrigated Lawn and Turf Seed

Seed Type	Blend Percentage
Kentucky Blue Grass	7
Tall Fescue	88
Perennial Rye Grass	5

(D) Type A Seed.
Type A seed shall be turf-type fescue or perennial rye grass having a minimum purity of ninety (90) percent.

(E) Type B Seed.
Type B seed shall be K-31, perennial rye grass, or smooth brome grass having a minimum purity as required by Table 802.03.

Table 802.03
Type B Seed Purity

Seed Type	Minimum Purity, %
K-31	90
Perennial Rye Grass	90
Smooth Brome Grass	80

(F) Hydraulic Seeding.
Seed for hydraulic seeding shall be perennial rye grass, alta fescue, smooth brome, crown vetch, and winter rye, wheat, or oats. The minimum purity shall comply with Table 802.04. Inoculate the crown vetch at four (4) times the manufacturer's recommended rate. Use of wheat is acceptable only for fall plantings. Use of oats is acceptable only for spring plantings. Use of winter rye is acceptable for spring or fall plantings.

Table 802.04
Hydraulic Seed Requirements

Seed Type	Minimum Purity, %	Blend, %
Perennial Rye Grass	90	18.2
Alta Fescue	80	18.2
Smooth Brome	70	18.2
Crown Vetch	90	27.2
Winter Rye or Wheat or Oats		18.2

(G) Fertilizer.
Fertilizer shall be an inorganic product containing sixteen (16) to eighteen (18) percent nitrogen and forty-six (46) to forty-eight (48) percent phosphoric acid in a recognized plant food form. Fertilizer shall comply with the current provisions of the Nebraska Fertilizer Act of 1955. Furnish and deliver fertilizer in standard weight bags or bulk. Provide a fertilizer certification form for every load of bulk fertilizer delivered to the project.

(H) Hay or Straw Mulch.
Hay or straw mulch shall be dry cured native hay, also known as prairie hay, or threshed grain straw. Straw shall be threshed straw of oats,

wheat, or rye. Hay or straw mulch shall be free of noxious weeds. Do not use hay or straw mulch in an advanced stage of decomposition that disintegrates or powders in the mulch blower.

Notify the Engineer of the hay source before delivering hay to the project. The Engineer reserves the right to reject the hay or straw source for any reason. Do not deliver hay or straw to the project until the Engineer has approved the hay source.

(I) Emulsified Asphalt.
Emulsified asphalt shall conform to the requirements for Type SS-1 as defined by ASTM D977, Standard Specification for Emulsified Asphalt. The emulsified asphalt shall be of a fluid consistency suitable for spray application with or without dilution with water. The emulsified asphalt shall not contain petroleum solvents or other dilution agents known to be toxic to plant life.

(J) Hydraulic Mulch.
Hydraulic mulch shall consist of wood fiber and water combined with grass seed, fertilizer, tackifier, and/or other additives. Wood mulch material shall consist of virgin wood fibers manufactured expressly from whole wood chips and processed to eliminate all growth- or germination-inhibiting factors. The mulch shall include a non-toxic tackifier that does not contain any growth- or germination-inhibiting factors. Adhere the tackifier to the fibers during manufacturing to prevent separation during shipment and to avoid chemical agglomeration during mixing in the hydraulic mulching equipment. The tackifier shall be homogeneous within the unit package. Use wood cellulose fibers that will maintain uniform suspension in water under agitation and blend with grass seed, fertilizer and other additives to form a homogeneous slurry. The slurry shall meet the requirements of Table 802.05.

Table 802.05
Hydraulic Mulch Requirements

Property	Requirement
Moisture Content, Percent	7 to 15
Wood Fiber Content, Minimum Percent	95
Tackifier Organic Content, Percent	2.5 to 4
Inorganic Content, Maximum Percent	1
pH, Average	4 to 6
Water Holding Capacity, Minimum Gallons per Pound of Fiber	1

Provide independent laboratory test results verifying the erosion control performance of the mulch/tackifier combination. The mulch/tackifier combination shall prevent erosion when tested using a rainfall simulator operating at four (4) inches of rainfall per hour. Use an application rate of one thousand six hundred (1,600) pounds of the mulch/tackifier combination per acre. The ground slope for the test shall be a 1V:2H slope with a soil composition of twenty-eight (28) percent sand, forty-nine (49) percent silt, and twenty-five (25) percent

clay. Do not use a mulch/tackifier combination that results in an apparent erosion rate greater than five (5) tons per acre per hour when tested using such conditions.

Upon application, the mulch material shall form a blotter-like mat covering the ground. This mat shall absorb moisture, percolate, and cover and hold grass seed in contact with the soil. Fibers produced from recycled material such as sawdust, paper, cardboard, or residue from pulp and paper plants are not acceptable. Dye the wood fiber mulch to be green in color. The dye shall be biodegradable and not inhibit plant growth. Package wood fiber mulch in units not exceeding one hundred (100) pounds. The packaging shall contain current labels, the manufacturer's name, and the net weight.

802.03 Construction Requirements.

(A) General.

Notify the Engineer a minimum of forty-eight (48) hours before commencing the work. Do not proceed with such work until authorized by the Engineer. Perform seeding operations from March 15 to May 31 or from September 1 to November 15 unless otherwise authorized in writing by the Engineer. Alternative dates authorized by the Engineer do not alter any warranty or establishment conditions or requirements. Perform dormant seeding after November 1. Do not perform seeding or fertilizing operations if the ground is wet, frozen, or otherwise untillable. Do not perform seeding or fertilizing operations when conditions do not allow for a uniform distribution of materials.

Prepare the seedbed by scarifying the upper two (2) inches of the soil in a manner acceptable to the Engineer a maximum of five (5) days before the sowing of seed. Perform disking, harrowing, and raking in the longitudinal direction on all slopes steeper than 1V:4H.

Apply mulch within twenty-four (24) hours after seeding unless otherwise directed by the Engineer. Place the mulch covering loose enough to allow sunlight to penetrate and air to circulate slowly. Place the mulch covering at a thickness that shades the ground, reduces the rate of evaporation, and prevents or reduces erosion due to water or wind. Furnish the equipment and assistance necessary for accurate placement of the specified quantities. Do not place mulch if, in the judgment of the Engineer, the wind velocity is too great to allow uniform distribution of the mulch materials.

(B) Establishment Period.

Maintain seeded areas for a minimum of six (6) months after application of the seeding materials. The Engineer reserves the right to accept seeded areas before completion of the six (6) month period. Re-seed and maintain any areas not moist or fully growing at or before the completion of the six (6) month period.

(C) Fertilizing.

Apply fertilizer using an approved mechanical spreader or hydraulic seeder uniformly over all areas receiving seed. Apply available nitrogen (N_2) at a rate of nine (9) pounds per one thousand (1,000) square yards. Apply phosphoric acid (P_2O_5) at a rate of twenty-four (24) pounds per one thousand (1,000) square yards. The Engineer reserves the right to alter the mixing proportions or application rates to meet site conditions. Do not blend any fertilizer without the Engineer present. Incorporate fertilizers into the soil before seeding.

(D) Seed Application.

Apply seed after fertilizing using approved mechanical power-drawn drills equipped with press wheels or drag chains, or broadcast-type seeders. Do not use hydraulic seeders without written authorization from the Engineer. Using a standard lawn roller, harrow or hand rake and compact any areas seeded using a broadcast-type seeder or hydraulic seeder. Apply seed in accordance with Table 802.06.

Table 802.06
Seed Application Rates

Seed Type	Application Rate Pounds of Pure Live Seed per 1000 Square Yards
Non-irrigated Lawn and Turf	108
Irrigated Lawn and Turf	108
Type A	
Turf-type Fescue	100
Perennial Rye Grass	10
Type B	
K-31	25
Perennial Rye Grass	10
Smooth Brome Grass	10
Hydraulic	108

Maintain a planting depth of one-half (½) to three-fourths (¾) inches when using a mechanical power-drawn drill.

Hydraulic seeding equipment shall include a pump of sufficient capacity and rating to maintain operation at one hundred (100) gallons per minute and at one hundred (100) pounds per square inch pressure, unless otherwise directed by the Engineer. The equipment shall have a suitable pressure gauge and a nozzle adapted to the type of work. Storage tanks shall have a means of estimating the volume used or remaining in the tank. Apply fertilizer separately from the seed when using a hydraulic seeder.

(E) Hay or Straw Mulch.

Place the mulch covering loosely enough to allow sunlight to penetrate and air to slowly circulate. Place the mulch covering at a thickness that shades the ground, reduces the rate of evaporation, and prevents or reduces erosion due to water or wind.

Apply mulch using a mulch-blowing machine or other methods acceptable to the Engineer. Apply hay at a rate of two (2) tons per acre. Apply straw at the rate of three (3) tons per acre.

Anchor the mulch using a mulch crimper or other approved equipment with dull disc blades without camber immediately after spreading. Use a mulch crimper equipped with a ballast compartment that allows an increase or decrease in the weight. Crimp mulch the same day that it is applied.

Apply asphalt emulsion anchors at a minimum temperature of thirty-two (32) degrees Fahrenheit and at a minimum rate of one hundred fifty (150) gallons per acre. Apply the material using a mulch-blowing machine capable of applying the hay or straw and the emulsified asphalt uniformly in the required quantities and in one operation. The machine shall be of a design approved by the Engineer and maintained in a satisfactory working condition. Do not use asphalt emulsion with Type A seeding.

(F) Hydraulic Mulch.
Mix the wood fiber mulch, seed, fertilizer, and water using standard hydraulic mulching equipment that forms a uniform slurry and continuously agitates all materials to maintain the materials in uniform suspension throughout the mixing and distribution cycles. Using standard hydraulic mulching equipment, uniformly apply the slurry over the soil surface in a single operation. The minimum mulch application rate shall be two thousand (2,000) pounds per acre. Increase the rate as necessary to provide the necessary texture and coverage.

802.04 Measurement and Payment.

The Engineer shall measure seeding for payment by the square yard area seeded, fertilized, mulched, and accepted.

Reseeding or overseeding to obtain a fully growing area is subsidiary to items for which the Contract provides direct payment. Fertilizer placed in conjunction with seeding is subsidiary to items for which the Contract provides direct payment. Mulch, including hay, straw, and/or hydraulic mulch, placed in conjunction with seeding is subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for the furnishing and applying of fertilizer; furnishing and sowing seed; furnishing and applying mulch materials; preparation of the seedbed; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Seeding – Type ___	Square Yard

THIS PAGE INTENTIONALLY LEFT BLANK

803 – SODDING

803.01 Description.

This work includes furnishing, cutting, mowing, and placing sod in accordance with and at the locations indicated in the Contract Documents or as directed by the Engineer.

803.02 Material Requirements.

(A) Sod.
Obtain sod from sources acceptable to the Engineer. The sod shall be a first-class representation of normal species or varieties of bluegrass. Grow sod using culturally planted bluegrass seed planted specifically for the production of bluegrass sod. Maintain the sod using culturally accepted methods for the production of bluegrass sod. Sod shall be free of noxious weeds and relatively free of all other weeds.

Fertilize the sod uniformly over all areas receiving seed using an approved mechanical spreader or hydraulic seeder. Apply available nitrogen (N_2) at a rate of nine (9) pounds per one thousand (1,000) square yards. Apply phosphoric acid (P_2O_5) at a rate of twenty-four (24) pounds per one thousand (1,000) square yards. The Engineer reserves the right to alter the mixing proportions or application rates to meet site conditions. Do not blend any fertilizer without the Engineer present.

(B) Fertilizer.
Fertilizer shall be an inorganic product containing sixteen (16) to eighteen (18) percent nitrogen and forty-six (46) to forty-eight (48) percent phosphoric acid in a recognized plant food form. Fertilizer shall comply with the current provisions of the Nebraska Fertilizer Act of 1955. Furnish and deliver fertilizer in standard weight bags or bulk. Provide a fertilizer certification form for every load of bulk fertilizer delivered to the project.

(C) Stakes.
Stakes shall be wood lathe and have a minimum length of eight (8) inches. Obtain the approval of the Engineer for any other types of stakes before using.

803.03 Construction Requirements.

Perform sodding operations from March 15 to June 15 or September 1 to December 1 unless otherwise authorized in writing by the Engineer. Alternative dates authorized by the Engineer do not alter any warranty or establishment conditions or requirements. Do not perform sodding operations if the ground is frozen, or during weather conditions unfavorable

for growth. Perform sodding operations as soon as possible after completing the finish grading on a section of the project.

Clear all areas receiving sod of debris and dead vegetation before preparing the sod bed. Place topsoil as required by the Contract Documents or directed by the Engineer during conditions favorable for grading and sodding. Before placing topsoil, scarify areas receiving topsoil to a minimum depth of two (2) inches. Remove large clods that will not break down, rocks, twigs, and other foreign material. Dress the entire surface to present a uniform appearance. Add water as necessary to facilitate shaping. The finished work shall conform to the lines, grades, slopes, and typical cross sections indicated in the Contract Documents. Correct surface irregularities to prevent the formation of depressions or water pockets. Compact any loose soils lightly to create a uniform sod bed. The sod bed shall not have a crusted appearance. Apply fertilizer to the sod bed at a rate of twenty (20) pounds per one thousand (1,000) square feet. Incorporate the fertilizer to a depth of one (1) inch. Treat the sod bed using a siduron pre-emergent grass herbicide. Apply the pre-emergent grass herbicide at the manufacturer's recommended rate. The Engineer reserves the right to approve alternative pre-emergent herbicides provided such herbicides do not interfere with seed germination of turf grasses.

Mow and rake the sod to remove stems, sticks, and grass clippings before cutting. When stripping, cut the sod one (1) to two (2) inches below the base of the grass stem. Use cutting procedures and equipment acceptable to the Engineer. Do not lay sod cut more than forty-eight (48) hours before laying or that has dry or dead edges. Sod shall be moist before cutting and shall be kept moist until placed. Handle, transport, and lay the sod to avoid unnecessary damage to and loss of earth from the roots of the sod.

Lay the sod over the sod bed with strips edge to edge in a compact mass. Lay the sod approximately one (1) inch below adjoining paved or seeded surfaces and flush with adjoining sod. Stake any sod placed on slopes steeper than 1V:3H or in ditch bottoms to prevent slippage. Drive stakes flush with the sod line and with the broad face of the stake facing the slope. Roll all sod not staked one (1) time using a sod roller approved by the Engineer.

Thoroughly water all sod immediately after placing. Water the sod during placement to cool the sod as necessary or required by the Engineer. Maintain sodded areas, including thorough watering, for a minimum of six (6) months after placement of the sod materials. The Engineer reserves the right to accept sodded areas before completion of the six (6) month period. Re-sod and maintain any areas not moist or fully growing at or before the completion of the six (6) month period. All sod must be moist and growing at the time of acceptance.

803.04 Measurement and Payment.

The Engineer shall measure sodding for payment by the number of square yards of sod supplied, installed, and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for furnishing the sod; for the preparation, fine grading, and leveling of the areas that receive sodding; for furnishing and applying the pre-emergent and fertilizer; for laying the sod; for furnishing and applying water; for all materials, labor, equipment, tools, stakes and staking if required; and for all incidentals necessary to complete the work.

Description	Unit
Sodding	Square Yard

THIS PAGE INTENTIONALLY LEFT BLANK

804 – PLANT MATERIALS

804.01 Description.

This work includes furnishing, collecting, delivering, and planting of plant materials; furnishing equipment; moving trees; and resetting trees; and all related operations as required by the Contract Documents or as directed by the Engineer. The nomenclature used in the Contract Documents shall be construed to conform to the standard nomenclature as compiled and published by the American Joint Committee on Horticulture Nomenclature in Standard Plant Names, 1942. Plant material shall mean trees, shrubs, vines, ground covers, and plants of all descriptions required to be furnished for the project by the Contract Documents or as directed by the Engineer.

804.02 Material Requirements.

(A) General.

All plant materials shall be "nursery-grown" unless otherwise indicated in the Contract Documents. Package plants in a manner that provides proper protection against freezing, drying, breaking, over-heating, or other injury. Use all necessary precautions consistent with accepted practices to ensure that the plant materials arrive at the destination in good condition for successful growth.

Wilt-proof all coniferous material before shipment from the source. Accompany each load of coniferous material with a nursery-signed affidavit stating the project number, date, and place of the wilt-proofing; and the number and type of materials covered by the affidavit. Remove and replace any coniferous material furnished without wilt-proofing at no additional cost to the City. The Engineer reserves the right to reject any coniferous materials furnished without the wilt-proofing affidavit. Transport all coniferous plant material using a covered conveyance.

(B) Nursery-Grown Plant Material.

All plant materials shall conform to the requirements outlined in the American Standard for Nursery Stock published by the American Association of Nurserymen, Inc. All plant material shall comply with all applicable local, state, and federal laws, including inspection certifications which shall include the project number and the plant material that the certification covers. The City reserves the right to allow inspection of any plant material by representatives of the City, State, and Federal Government.

All plant material furnished shall be true to name and type. Furnish legible labels that identify the species, varieties, boxes, bundles, bales, or other containers for all plant materials. The label shall identify the botanical genus, species, common name, and size or age of each

species or variety. All plant material shall be sound, healthy specimens and first-class representatives of their species or variety, and shall have well-formed tops and healthy root systems. Do not provide plant materials that have improper proportions, serious injuries to the bark or roots, broken branches, objectionable disfigurements, shriveled dry roots, broken balls, insect pests, and/or diseases; or do not comply with these specifications. Remove any rejected plant material from the project as soon as practicable.

Submit a representative sample of all container-grown and/or pot-grown materials to the Engineer for approval before planting. The Engineer reserves the right to internally examine any container-grown, pot-grown, and balled and burlapped plant material at any time to ascertain the condition of the roots and the soil around the roots.

Plant materials shall be fresh dug materials whenever possible. Do not provide stored plant material if excessive growth has occurred during storage. Replace plant materials with excessive growth at no additional cost to the City.

Do not injure or remove fibrous roots from the plant material unnecessarily. Replace plant materials that have unnecessary injuries or removals at no additional cost to the City.

Maintain the condition of the soil used for balled, container-grown, or Q-pot-grown material in a manner that prevents crumbling or cracking. Wrap balls with burlap before removing from the ground. Hold the burlap in place using cords or pinning nails. Handle balled and burlapped material in a manner to keep the soil intact. Replace plant material on which the ball has cracked or crumbled at no additional cost to the City.

(C) Collected Plant Material.

Collected plant material shall be non-nursery grown plant material including coniferous plant material grown for holiday trees that has not received the normal transplanting and root pruning given nursery-grown plant materials. Furnish collected plant material only when specifically indicated by the Contract Documents. The Engineer reserves the right to inspect the proposed collected plant material before removal from the existing location. Collected plant material shall be dug in accordance with the applicable portions of the American Standards for Nursery Stock published by the American Association of Nurserymen, Inc.

(D) Fertilizer.

Fertilizer shall be an inorganic product containing sixteen (16) to eighteen (18) percent nitrogen and forty-six (46) to forty-eight (48) percent phosphoric acid in a recognized plant food form. Fertilizer shall comply with the current provisions of the Nebraska Fertilizer Act

of 1955. Furnish and deliver fertilizer in standard weight bags or bulk. Provide a fertilizer certification form for every load of bulk fertilizer delivered to the project.

Pre-planting fertilizer shall be pressure-formed pellets containing twenty (20) percent nitrogen (N_2), ten (10) percent available phosphoric Acid (P_20_5), five (5) percent water soluble potash (K_20), and a minimum of thirteen (13) percent water insoluble nitrogen. Each pellet shall weigh between twenty (20) and twenty-two (22) grams.

Post-planting fertilizer shall conform to the requirements of Table 804.01.

Table 804.01
Fertilizer Requirements

Property	Requirement
Total Nitrogen (N_2), Minimum Percent	12
Water Insoluble Nitrogen, Minimum Percent	2.1
Nitrogen derived from urea formaldehyde, Minimum Percent	25
Available Phosphoric Acid (P_20_5), Minimum Percent	4
Water Soluble Potash (K_20), Minimum Percent	8
Allowable Secondary Nutrients	Ca, Mg. S
Allowable Micro Nutrients	B, Cu, Fe, Mn, Zn

Post-installation fertilizer shall be a liquid urea comprised of twenty-eight (28) to thirty-two (32) percent nitrogen (N_2). Mix the liquid urea with water at a ratio of one (1) part liquid urea to three hundred (300) parts water.

(E) Peat Moss.
Peat moss shall be a granular commercial type, dark in color, and have a pH between five and one-half (5.5) and seven and one-half (7.5). Peat moss shall conform to all applicable sections of ASTM D5539, Standard Specification for Seed Starter Mix. Supply peat moss in sealed fifty (50) pound bags.

(F) Wood Chip Mulch.
Wood chip mulch shall be wood shaving, wood chips, tree bark or shredded bark consisting of bark, wood, and incidental wood particles obtained from mechanical shaving, debarking, or chipping operations of either hardwood of softwood trees. Wood chip mulch shall be reasonably free of leaves, twigs, sawdust, toxic substances, or other foreign materials. Do not subject wood chip mulch to any condition that would cause it to lose its value as mulch.

(G) Hose and Guy Wiring.
Stakes used for guy wiring shall be wood and approximately one and five-eighths ($1\frac{5}{8}$) inch by one and five-eighths ($1\frac{5}{8}$) inch. For deciduous trees less than two (2) inches in caliper and coniferous trees less than eight (8) feet in height use stakes with a minimum length of nine (9) inches. For deciduous trees two (2) inches in caliper and larger

and coniferous trees eight (8) feet and taller use stakes with a minimum length of eighteen (18) inches. The guy wires shall be fourteen (14) gauge, soft drawn wire. Hose shall be nylon, rubber, or reinforced plastic with a minimum inside diameter of one-half (½) inch and minimum length of six (6) inches. The Engineer reserves the right to accept commercial plant ties in lieu of guy wires.

(H) Tree Wrap.
Tree wrap shall be crinkled waterproof paper comprised of two sheets cemented together with asphalt with a minimum weight of four (4) pounds per one hundred (100) square feet.

804.03 Construction Requirements.

(A) General.
Plant deciduous materials between March 1 to May 1 and October 1 to December 1. Plant coniferous materials between March 1 to May 15 and August 15 to September 30. Do not plant materials outside of these periods without prior written approval by the Engineer. Suspend the work during periods of excessive winds, excessive moisture in the soils, frozen ground, or when the prevailing weather would likely cause unsatisfactory results.

Remove and replace any planted materials that are not true to name at no additional cost to the City. Submit a written list of the nurseries proposed to provide the plant materials and the source where the plant materials are grown. Do not purchase plant materials until receiving written notice from the Engineer stating that the nursery and the source are acceptable. Remove and replace any plant material furnished from an unapproved nursery or source at no additional cost to the City.

(B) Transporting Plant Materials.
Cover all bare-root stock sent from the storage facility using wet soil, sawdust, wood chips, shingle toe, moss, peat, straw, hay or other acceptable moisture-holding media and a tarpaulin or canvas. The Engineer reserves the right to reject any unprotected loads.

(C) Receiving and Storing Plant Materials.
Store all plant materials not planted immediately upon delivery. Storage facilities shall have an adequate water supply, shade, good ventilation, and protection from drying winds. The Engineer shall approve of the storage facilities before delivering plant materials to the storage facilities. Store all bare-rooted plant materials by dipping in a mud and water slurry immediately upon arrival and before storage. Protect the stored plant materials using wet soil, sawdust, wood chips, shingle toe, moss, peat, straw, hay or other acceptable moisture holding media. Keep stored plant materials well watered.

Do not remove plant materials from storage before completing the preparation of the planting site for proper and immediate planting. Protect plant materials from freezing, drying, breaking, overheating, and other injuries.

(D) Planting.

Prepare the areas to receive planting by tilling any existing vegetation into the soil to a minimum depth of two (2) inches. Excavate the hole for the plant material in the tilled area to the dimensions indicated in the Contract Documents or as directed by the Engineer. Place pre-planting fertilizer in the excavated hole in a manner and location that will avoid direct contact with the root system. Use three (3) pellets per plant for all shrubs and vines. Use eight (8) pellets per plant for all trees less than two (2) inches in caliper or less than eight (8) feet in height. Use ten (10) pellets per plant for all trees two (2) inches in caliper or larger or eight (8) feet or greater in height.

Position the plant material vertically plumb. Place balled and burlapped material in a manner that causes the ball to crack and pull away from the roots. The Engineer reserves the right to reject damaged balled and burlapped materials. Remove and reset trees using a mechanical tree spade acceptable to the Engineer and having a manufacturer's size rating equal to or exceeding the tree sizes. Place peat moss as indicated by the Contract Documents or as directed by the Engineer.

When backfilling balled and burlapped plant material, remove all twine from the trunk and pull the burlap away from the trunk before completing the backfilling operation. When backfilling bare-rooted plant material, examine the roots and cleanly prune any bruised or broken roots. Accomplish backfilling with care to avoid breaking, bruising, or otherwise damaging the roots or other parts of the plant materials when firming the soil. Construct a watering basin for all plant material. Scatter and level any surplus material from the excavation to leave a neat, smooth appearance. Fill the water basin with water before installing the post-planting fertilizer.

Place post-planting fertilizer before placing the mulch. Place one-half (½) pound per plant for all shrubs and vines. Place one (1) pound per plant for all trees less than two (2) inches in caliper or less than eight (8) feet in height. Place two (2) pounds per plant for all trees two (2) inches in caliper or larger or eight (8) feet or greater in height.

An experienced pruner acceptable to the Engineer shall properly and systematically prune all deciduous plant materials. The Engineer reserves the right to reject any planted material that does not meet the specified minimum size before pruning. Replace rejected plant materials at no additional cost to the City. Perform pruning using the process of thinning to maintain and preserve the characteristic shape

and natural form of the plant material as indicated in the Contract Documents or directed by the Engineer. Use a sharp tool to perform all pruning cuts. Paint any cut surfaces greater than one (1) inch in diameter with a standard pruning compound approved by the Engineer. Dispose of all cuttings removed by pruning in a manner and location acceptable to the Engineer.

Wrap the tree trunk of all deciduous trees over three-fourths (¾) inch caliper from six (6) inches below ground to approximately one-half (½) the height of the tree or the first well-developed branch that remains after pruning. Overlap the wrap a minimum of one-third (⅓) the width of the tree wrap. Securely fasten the wrapping using masking tape or approved equal at the top, middle, bottom, and as needed. Do not use staple or nylon-reinforced strapping tape to fasten the wrapping.

Water-in all planted plant material no later than noon of the following day. The Engineer reserves the right to reject any plant materials not watered-in by noon of the following day. Cease planting operations until watering is current when watering fails to meet the specified time limit. Maintain the plant materials in a moist condition as dictated by weather conditions, soil conditions, or as directed by the Engineer until final acceptance of the plant material. Water all plant material every ten (10) days during the establishment period.

Construct tree rings as indicated in the Contract Documents. Tree ring construction is subsidiary to items for which the Contract provides direct payment. Stake and guy all deciduous and coniferous trees upon completion of the first watering in accordance with the Contract Documents or as directed by the Engineer. Drive the stakes so that they are firm and provide support to the trees. Do not penetrate the ball or roots of the trees with the stakes. Install guys sufficiently tight to transfer support from stake to tree.

Mulch all plant material using wood chip mulch. Place wood chip mulch four (4) inches deep across all disturbed earth or as directed by the Engineer. Apply the mulch after completing the post-planting fertilizer application and subsequent watering.

(E) Establishment Period.

The establishment period will not begin until completion of all proper planting, backfilling, fertilizing, watering, pruning, wrapping, staking, guying, water basin construction, and mulching required in the Contract Documents on every plant material. All plant material shall be in an acceptable growing condition when the project enters the establishment period. The establishment period shall last until June 1 of the following year. The City reserves the right to extend the establishment period by one (1) additional year for failure to maintain the plant material as required by the Contract Documents. Replace all unacceptable plant material in the spring planting season. All

replacement plant material shall receive a minimum of thirty (30) days establishment before final acceptance.

During the establishment period, maintain all plant materials planted under the Contract. Maintenance includes additional pruning, pest and disease prevention and treatment, watering, fertilizing, cultivating, watering basin repair, wrap and mulch replacement, stakes and the guys adjustment, weeding, weed treatment, and other establishment procedures deemed necessary by the Engineer. Remove any dead plant material from the project. Accomplish weed treatment using a pre-emergent weed control or other means acceptable to the Engineer.

(F) Post Installation Fertilizing.
Between March 1 and June 1 of the year following the year of planting the plant materials, fertilize all trees and shrubs using a liquid solution pumped into the soil under pressure. Meter the solution to verify the application rate. Inject the solution into the soil at a depth of approximately eighteen (18) inches. Apply one (1) gallon of solution per foot of spread for coniferous shrubs. Apply one (1) gallon of solution per foot of height for coniferous trees and deciduous shrubs. Apply five (5) gallons of solution per caliper inch for deciduous trees.

804.04 Measurement and Payment.

The Engineer shall measure plant materials for payment as single units defined by each specific plant item furnished, planted, and accepted.

The Engineer shall measure removing and resetting trees as single units defined by each tree removed, reset, and accepted.

The Engineer shall measure peat moss for payment as a single unit defined by each fifty (50) pound bag supplied, installed, and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This contract price shall be full compensation for collecting, backfilling, watering, fertilizing, pruning, wrapping, staking, guying, wood chip mulching, water basin preparation, and establishment period; and furnishing all labor, materials, equipment, tools, incidentals necessary to complete the work.

Description	Unit
___ Plant Material	Each
Remove And Reset Trees	Each
Peat Moss	Each

THIS PAGE INTENTIONALLY LEFT BLANK

805 – MULCH

805.01 Description.

Lava rock mulch includes supplying and placing lava rock mulch as indicated in the Contract Documents or as directed by the Engineer. Hay or straw mulch includes supplying and placing hay or straw mulch as indicated in the Contract Documents or as directed by the Engineer. Hydraulic mulching includes supplying and placing a mixture of wood fiber mulch, grass seed, fertilizer and/or other additives with water.

805.02 Material Requirements.

(A) Lava Rock Mulch.
Lava rock mulch shall consist of red scoria lava rock with a gradation ranging from one-half (½) inch to one and one-half (1½) inch.

(B) Hay or Straw.
Hay or straw mulch shall be dry cured native hay, also known as prairie hay, or threshed grain straw. Straw shall be threshed straw of oats, wheat, or rye. Hay or straw mulch shall be free of noxious weeds. Do not use hay or straw mulch in an advanced stage of decomposition that disintegrates or powders in the mulch blower.

Notify the Engineer of the hay source before delivering hay to the project. The Engineer reserves the right to reject the hay or straw source for any reason. Do not deliver hay or straw to the project until the Engineer has approved the hay source.

(C) Wood Chip Mulch.
Wood chip mulch shall be wood shaving, wood chips, tree bark, or shredded bark consisting of bark, wood, and incidental wood particles obtained from mechanical shaving, debarking, or chipping operations of either hardwood or softwood trees. Wood chip mulch shall be reasonably free of leaves, twigs, sawdust, toxic substances, or other foreign materials. Do not subject wood chip mulch to any condition that would cause it to lose its value as mulch.

(D) Emulsified Asphalt.
Emulsified asphalt shall conform to the requirements for Type SS-1 as defined by ASTM D977, Standard Specification for Emulsified Asphalt. The emulsified asphalt shall be of a fluid consistency suitable for spray application with or without dilution with water. The emulsified asphalt shall not contain petroleum solvents or other dilution agents known to be toxic to plant life.

(E) Hydraulic Mulch.

Hydraulic mulch shall consist of wood fiber and water combined with grass seed, fertilizer, tackifier, and/or other additives. Wood mulch material shall consist of virgin wood fibers manufactured expressly from whole wood chips and processed to eliminate all growth- or germination-inhibiting factors. The mulch shall include a non-toxic tackifier that does not contain any growth- or germination-inhibiting factors. Adhere the tackifier to the fibers during manufacturing to prevent separation during shipment and to avoid chemical agglomeration during mixing in the hydraulic mulching equipment. The tackifier shall be homogeneous within the unit package. Use wood cellulose fibers that will maintain uniform suspension in water under agitation and blend with grass seed, fertilizer, and other additives to form a homogeneous slurry. The slurry shall meet the requirements of Table 805.01.

Table 805.01
Hydraulic Mulch Requirements

Property	Requirement
Moisture Content, Percent	7 to 15
Wood Fiber Content, Minimum Percent	95
Tackifier Organic Content, Percent	2.5 to 4
Inorganic Content, Maximum Percent	1
pH, Average	4 to 6
Water Holding Capacity, Minimum Gallons per Pound of Fiber	1

Provide independent laboratory test results verifying the erosion control performance of the mulch/tackifier combination. The mulch/tackifier combination shall prevent erosion when tested using a rainfall simulator operating at four (4) inches of rainfall per hour. Use an application rate of one thousand six hundred (1,600) pounds of the mulch/tackifier combination per acre. The ground slope for the test shall be a 1V:2H slope with a soil composition of twenty-eight (28) percent sand, forty-nine (49) percent silt, and twenty-five (25) percent clay. Do not use a mulch/tackifier combination that results in an apparent erosion rate greater than five (5) tons per acre per hour when tested using such conditions.

Upon application, the mulch material shall form a blotter-like mat covering the ground. This mat shall absorb moisture, percolate, and cover and hold grass seed in contact with the soil. Fibers produced from recycled material such as sawdust, paper, cardboard, or residue from pulp and paper plants are not acceptable. Dye the wood fiber mulch to be green in color. The dye shall be biodegradable and not inhibit plant growth. Package wood fiber mulch in units not exceeding one hundred (100) pounds. The packaging shall contain current labels, the manufacturer's name, and the net weight.

805.03 Construction Requirements.

(A) General.

Apply mulch within twenty-four (24) hours after seeding unless otherwise directed by the Engineer. Place the mulch covering loosely enough to allow sun light to penetrate and air to circulate slowly. Place the mulch covering at a thickness that shades the ground, reduces the rate of evaporation, and prevents or reduces erosion due to water or wind. Furnish the equipment and assistance necessary for accurate placement of the specified quantities. Do not place mulch if, in the judgment of the Engineer, the wind velocity is too great to allow uniform distribution of the mulch materials.

(B) Lava Rock.

Carefully place lava rock mulch in a manner that avoids harming any plant materials within the prepared area. Place lava rock mulch a minimum of two (2) inches thick in a manner that covers the entire ground.

(C) Hay or Straw.

Apply mulch using a mulch-blowing machine or other methods acceptable to the Engineer. Apply hay at a rate of two (2) tons per acre. Apply straw at the rate of three (3) tons per acre.

Immediately after spreading, anchor the mulch using a mulch crimper or other approved equipment with dull disc blades without camber. Use a mulch crimper equipped with a ballast compartment that allows an increase or decrease in the weight. Crimp mulch the same day that it is applied.

Apply asphalt emulsion anchors at a minimum temperature of thirty-two (32) degrees Fahrenheit and at a minimum rate of one hundred fifty (150) gallons per acre. Apply the material using a mulch-blowing machine capable of applying the hay or straw and the emulsified asphalt uniformly in the required quantities and in one operation. The machine shall be of a design approved by the Engineer and maintained in a satisfactory working condition. Do not use asphalt emulsion with Type A seeding.

(D) Wood Chip Mulch.

Carefully place wood chip mulch in a manner that avoids harming any plant materials within the prepared area. Place wood chip mulch a minimum of four (4) inches thick in a manner that covers the entire ground.

(E) Hydraulic Mulching.

Mix the wood fiber mulch, seed, fertilizer, and water using standard hydraulic mulching equipment that forms a uniform slurry and continuously agitates all materials to maintain the materials in uniform

suspension throughout the mixing and distribution cycles. Using standard hydraulic mulching equipment, uniformly apply the slurry over the soil surface in a single operation. The minimum mulch application rate shall be two thousand (2,000) pounds per acre. Increase the rate as necessary to provide the necessary texture and coverage.

805.04 Measurement and Payment.

The Engineer shall measure lava rock mulch for payment by the square feet of material supplied, installed, and accepted.

The Engineer shall measure hay or straw mulch for payment by the square feet of hay or straw mulch supplied, installed, and accepted.

The Engineer shall measure wood chip mulch for payment by the square feet of hydraulic mulch supplied, installed, and accepted.

The Engineer shall measure hydraulic mulch for payment by the square feet of hydraulic mulch supplied, installed, and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This contract price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Lava Rock Mulch	Square Foot
Hay or Straw Mulch	Square Foot
Wood Chip Mulch	Square Foot
Hydraulic Mulch	Square Foot

806 – RIP RAP

806.01 Description.

This work includes furnishing and constructing slope protection at locations and in conformance with the alignment, grade, and typical cross sections indicated in the Contract Documents or as directed by the Engineer using crushed aggregate, broken PCC, or sacked PCC.

806.02 Material Requirements.

(A) Stone and Broken PCC.

Evaluate aggregate and broken PCC in accordance with ASTM D4992, Standard Practice for Evaluation of Rock to be Used for Erosion Control. Do not use aggregate or broken PCC having a length to width, length to height, or width to height ratio greater than 3:1. Perform petrographic analysis only when requested by the Engineer. Aggregate shall be sandstone, limestone, quartzite, or other hard stone of good quality that is free of earth, clay, or refuse and does not disintegrate under action of air or water. Obtain aggregate from quarries acceptable to the Engineer. Use either aggregate or broken PCC, not a combination of both.

Aggregate and broken PCC shall conform to the requirements of Table 806.01. The Engineer reserves the right to accept past testing and service records to determine the acceptability of quarry aggregate. Ship the aggregate or broken PCC in a manner that avoids segregation. The aggregate or broken PCC shall be angular in shape to permit interlocking between the various rock sizes. Process the aggregate or broken PCC to meet the size requirements defined by the Contract Documents and determined in accordance with ASTM D6092, Standard Practice for Specifying Sizes of Stone for Erosion Control. Size broken PCC by pulverizing slabs of PCC removed from the project or other projects.

Table 806.01
Physical Property Requirements

Physical Property	Acceptable Range
Sodium Sulfate Soundness, (5 cycles)*	10.0% maximum loss
Magnesium Sulfate Soundness, (5 cycles)*	15.0% maximum loss
Freeze-Thaw Soundness, (25 cycles)*	15.0% maximum loss
LA Abrasion, ASTM C131 and ASTM D535	40.0% maximum loss
Bulk Specific Gravity	2.40 minimum
Absorption, ASTM C127 and ASTM C128	3.0% maximum

*Only one of the three soundness requirements must be fulfilled.

(B) Sedum Stoloniferum Plants.

Sedum stoloniferum plants to be planted in the earth fill between stones shall be well established and acclimated to outside conditions and shall be approved by the Engineer before planting.

806.03 Construction Requirements.

Obtain and deliver representative samples of the stone to the Engineer a minimum of thirty (30) calendar days before commencing placement of the stone. The Engineer shall approve all stone before delivery to the site.

Dump the approved aggregate or broken PCC in a manner that produces a reasonably uniform layer of rip rap within the limits indicated in the Contract Documents or as directed by the Engineer. Place the aggregate or broken PCC in contact with each other using earth fill as required to fill all voids. Place and distribute the aggregate or broken PCC in a manner that avoids large accumulations of either larger or smaller sized materials. Correct any appreciable variation from the specified thickness by redistributing the aggregate or broken PCC. Remove any exposed reinforcing steel bars or wire mesh projecting from the broken PCC in a manner acceptable to the Engineer.

Plant sedum stoloniferum plants amongst the rip rap in two and one-half (2½) inch bands or pots at twelve (12) inches on centers. Water the plants in at the time of planting.

806.04 Measurement and Payment.

When indicated in the Contract Documents, the Engineer shall measure rip rap for payment as a single unit defined as the number of tons of rip rap supplied, placed, and accepted. The Engineer shall determine tonnage based upon certified load tickets collected at the time of delivery that identify the source of the rip rap material, the date, the contractor, the project number, the tare weight of the transport vehicle, and the weight of the material delivered in tons. Accomplish all weighing using certified scales. The Engineer reserves the right to verify the ticketed weight. Weigh all materials delivered using rail cars or other bulk methods less any wasted tonnage using a certified scale acceptable to the Engineer at no additional expense to the City.

When indicated in the Contract Documents, the Engineer shall measure rip rap for payment as a single unit defined as the number of square yards of rip rap supplied, placed, and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for furnishing, preparing, additional pulverizing, loading, hauling, and placing all materials, including sedum; and for all labor, materials equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Construct ___ Rip-Rap - Type ___	Ton
Construct ___ Rip-Rap - Type ___	Square Yard

807 – PCC SLOPE PROTECTION

807.01 Description.

This work includes the construction of PCC slope protection including pavement and turndowns at the locations indicated in the Contract Documents or as directed by the Engineer.

807.02 Material Requirements.

(A) Portland Cement for PCC.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3.

(B) Water for PCC.
All water used in the concrete mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(C) Aggregate for PCC.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(D) Admixtures for PCC.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride flake in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC.

Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(E) PCC Mix Proportioning.

Proportion PCC mixtures to meet the requirements of Table 807.01.

Table 807.01
Concrete Properties

Mix Type	SG65	L6
Portland Cement Content, lbs. per cubic yard	611 min.	564 min.
Coarse Aggregate, % of Total Aggregate	0	30±3
Fine Aggregate, % of Total Aggregate	100	70±3
Maximum Water Cement Ratio	0.45	0.45
Minimum 28-Day Compressive Strength, psi	3500	3500
Air Content, %	6.5±1.0	6.5±1.0
Slump, inches	1.5±1.5	1.5±1.5
Concrete Temperature during placement, °F	70±20	70±20

Referenced Test Procedures:

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(F) Reinforcing Steel for PCC.

Reinforcing steel shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

(G) Pre-molded Joint Filler.

Pre-molded joint filler for expansion joints shall conform to the requirements of ASTM D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). Neatly punch holes to admit the dowels where indicated in the Contract Documents. The diameter of the holes shall not exceed one-half (½) inch greater than the

bar diameter. When more than one piece is required for a joint, securely fasten the abutting ends by stapling or other positive fastening means satisfactory to the Engineer.

(H) Joint Sealant.

Joint sealant shall be a polyurethane, silicone, or bitumastic liquid material intended for use as a PCC pavement sealant and shall conform to the requirements of C920, Standard Specification for Elastomeric Joint Sealants; ASTM D5893, Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements; or ASTM D6690, Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

(I) Curing Materials for PCC.

Curing materials shall be liquid membrane-forming compounds or polyethylene film. Liquid membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

807.03 Construction Requirements.

(A) Equipment.

Provide all equipment, labor, and tools necessary to perform the work to the satisfaction of the Engineer. The National Ready Mixed Concrete Association shall certify that the production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

The production facility shall provide the batch information for each load of PCC delivered to the site. The batch information shall accompany each load delivered to the site. At a minimum, the batch information shall include the component materials, the actual batch weights and target batch weights of component materials, free moisture content of aggregates, water cement ratio of batch, and amount of additional water added at production facility after batching.

Vibrators shall be internal, tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring

vibratory frequency available on the jobsite at all times. Use an internal tube vibrator whenever a vibrating screed is used.

Joint cutting saws shall use a water-cooled, diamond-tipped blade. Saws shall have an adjustable guide pointer. Keep a minimum of two (2) operational saws on-site at all times.

Hot-applied joint sealant applicators shall consist of a double-walled melting pot with a mechanical agitator that continuously stirs the material. The heating unit shall not apply direct heat to the sealant material. Applicators shall use a pressurized system for placing the material. Applicators shall have flow controls that allow the operator to control the flow of the heated material. Use an applicator nozzle that fills the joint from the bottom to the top. Cold-applied joint sealant applicators shall conform to the requirements established by the sealant manufacturer.

Keep a sufficient number of ten (10) foot straightedges and a six (6) inch steel channel master straightedge with a minimum length of ten (10) feet on site at all times.

(B) Forms for PCC.

Forms shall be rigid, straight metal. The maximum deflection of forms shall not exceed one-eighth ($^1/_8$) inch in ten (10) feet when tested as a simple beam and subjected to a center load of one thousand seven hundred (1,700) pounds. Clean and oil forms before PCC placement.

The minimum length shall be ten (10) feet. The depth shall be equivalent to the design thickness at the edge of the PCC. Bolt additional forms to the top of a form to achieve additional depth. Use a minimum of three (3) anchors for each individual form.

Radius forms may be comprised of wood or metal. Wood radius forms shall be rigid and finished on the concrete side of the form. The rigidity of the radius forms shall be as needed to resist deformation under the concrete load. Anchor radius forms as necessary to maintain the shape of the radius.

Bed and join forms neatly and tightly to line and grade in a manner that resists movement. Do not place forms on pedestals to maintain proper grade. Remove and reset forms that vary more than one-eighth ($^1/_8$) inch in ten (10) feet from line or grade.

The Contractor may use the edge of existing PCC as a form provided the existing PCC has a smooth vertical face or a keyed face that is free of soil or other contaminants.

Form concrete turndowns by excavating trenches in the ground without the use of forms. Fill trenches excavated larger than required with PCC placed with the turndown at no additional expense to the City.

(C) Pre-formed Expansion Joints.

Construct pre-formed expansion joints at the locations indicated in the Contract Documents. Place the pre-molded joint filler across the transverse length of the pavement and extend from one (1) inch below the pavement surface to the bottom of the pavement. Maintain the position of the pre-molded joint filler in a manner acceptable to the Engineer. The Contractor shall shape the pre-molded joint filler to match the shape of the integral curb attached to the pavement.

After placing the concrete, place joint sealant atop the pre-molded joint filler to one-fourth (¼) inch below the pavement surface.

(D) Pressure Relief Joints.

Construct pressure relief joints at the locations indicated in the Contract Documents. The longitudinal width of the pressure relief joint shall be four (4) inches with an allowable deviation of one-fourth (¼) inch at the time of construction. The pressure relief joint shall extend throughout the full width and depth of the surrounding pavement.

The surrounding surfaces shall be dry and free of dirt, grease, or other contaminants. The Contractor shall install the pressure relief joint filler in accordance with the manufacturer's instructions.

(E) Placing Reinforcing Steel.

Place steel reinforcement as directed by the Contract Documents. Overlap adjacent sheets of wire fabric a minimum of twelve (12) inches. Keep sheets straight during and after installation. The Contractor shall tie lapped sheets using steel wire or other material acceptable to the Engineer. Tie longitudinal laps at a spacing of twenty-four (24) inches or less. Tie transverse laps at a spacing of forty-eight (48) inches or less.

Place the reinforcement a maximum of three (3) inches from a longitudinal construction or expansion joint and a maximum of two (2) inches from a transverse construction or expansion joint. Place the reinforcement within one-fourth (¼) inch of the elevation required in the Contract Documents. The Contractor shall position the reinforcement before placing the PCC. Use metal supports acceptable to the Engineer to maintain the position of the reinforcement. Do not place any load on positioned reinforcement that causes the reinforcement to move out of position. Maintain the position of the reinforcement before, during, and after PCC placement.

(F) Placing PCC.

Before commencing PCC placement, adjust all appurtenances to the required grade and alignment. The Contractor may form the area around the appurtenance to allow for adjusting later. Construct a PCC header sized and located as indicated in the Contract Documents.

Provide sufficient lighting for PCC placement and finishing operations as instructed by the Engineer. Do not place PCC at night or in low-light situations without the Engineer's permission.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement, construction joints, headers, and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Moisten the face of construction joints to achieve a saturated surface-dry condition immediately before PCC placement. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, including wire mesh, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

For evaporation rates greater than two-tenths pounds per square feet per hour (0.2 lbs/ft^2/hr), take precautions against shrinkage cracking acceptable to the Engineer. Determine the evaporation rate in

accordance with Figure 2.1.5 of ACI 305, Hot Weather Concreting shown below.[12]

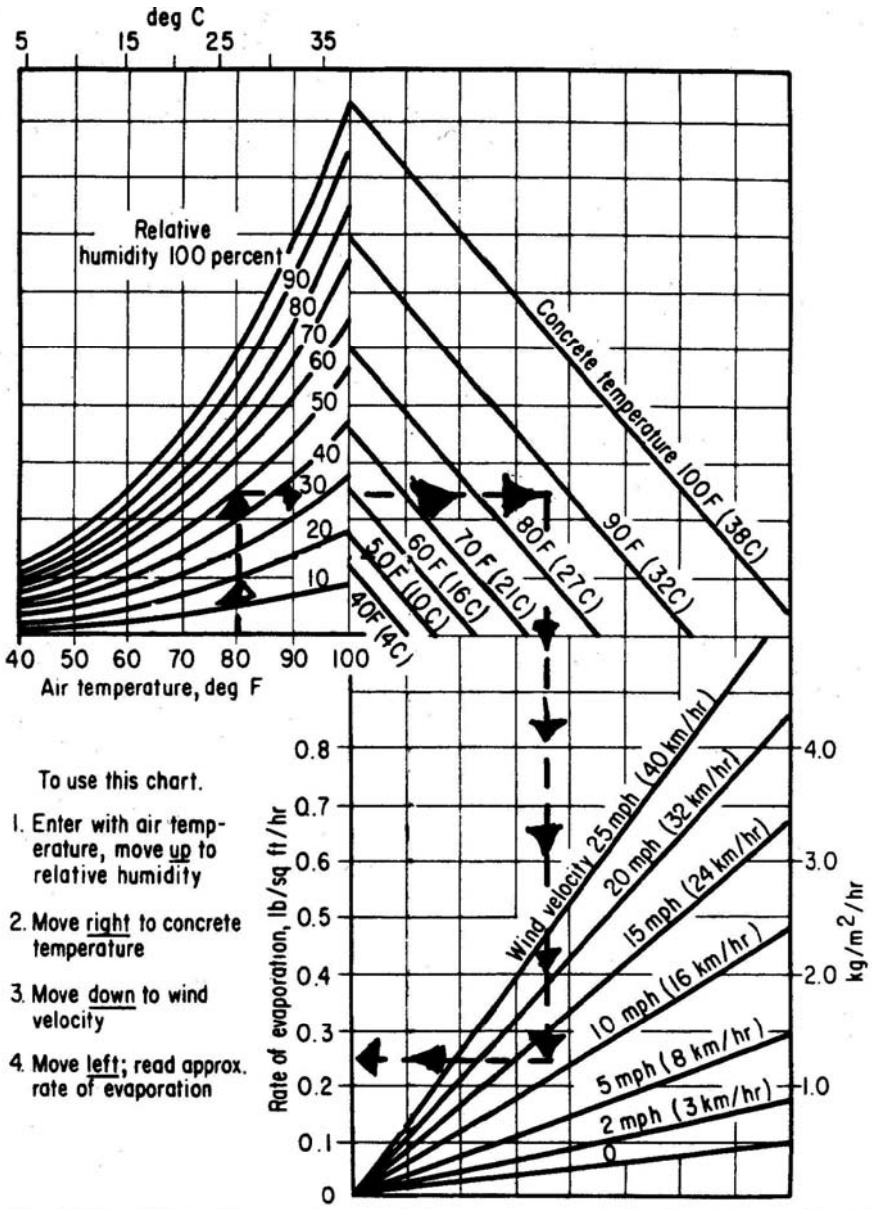

Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/hr (1 kg/m²/hr), precautions against plastic shrinkage cracking are necessary (Lerch 1957)

[12] Figure reprinted with written permission from ACI International.

During cold weather periods, do not commence PCC placement until the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature falls below forty (40) degrees Fahrenheit. Do not place PCC on frozen materials.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows the placement and finishing operations to continue as uninterrupted as possible. Place the PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the concrete in a manner that minimizes segregation. Construct turndowns simultaneously with the PCC slope protection.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Do not add water to loads not accompanied by the batch weight information. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

After placing and before striking off, consolidate PCC using internal vibration provided by one (1) or more tube vibrators. Insert and immediately remove manual vibrators at regular intervals less than

three (3) feet apart. Do not drag manual vibrators through the PCC. Use machine-mounted vibrators in accordance with the manufacturer's recommendations. Use a tube vibrator when using a vibrating screed.

Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC.

At the completion of the placement or if the placement is interrupted by more than thirty (30) minutes, place a transverse construction joint extending the full width and depth of the placement. Locate transverse construction joints at the location of the closest joint indicated in the Contract Documents.

(G) Finishing, Curing, and Protecting Concrete Pavement.

Strike off and finish the PCC to the elevation specified in the Contract Documents using a wood template or wooden screed. Hand finish as necessary. Remove material build-up from the forms before strike off or finishing begins. Finish the top surface of the PCC using a wood or metal float.

Immediately after finishing, true the surface using a ten (10) foot straightedge placed parallel and perpendicular to the direction of placement. Round the edges of the PCC surface using a one (1) inch diameter edging tool. Correct any irregularities in the surface and finish as needed.

Minimize screeding, floating, and troweling operations to avoid overworking or over-manipulation of the PCC. Remove any free water present on the PCC surface between finishing operations in a manner acceptable to the Engineer. Do not use neat cement or sand-cement mixtures to remove free water. Do not use finishing tools on PCC having free water present on the surface.

Apply an evaporation retardant acceptable to the Engineer to the surface as necessary. Minimize the amount of water added to the PCC surface to aid in finishing. Add an evaporation retardant or water by misting. Immediately remove excessive amounts of water as determined by the Engineer in a manner acceptable to the Engineer. Do not conduct finishing operations if free water is present on the concrete surface.

Upon completion of the finishing operation, texture the concrete surface by a wet, double-burlap drag or broom-finish. Drag the burlap parallel to the placement direction. Broom-finish the surface uniformly and perpendicular to the placement direction. Mist water on the burlap to maintain adequate moisture in the burlap. Do not pressure spray water onto any burlap that is atop fresh concrete. Clean the burlap and

brooms as needed to prevent build-up. Replace the burlap or broom if the build-up mars the PCC surface.

Within one (1) hour of PCC placement, protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer.

(H) Contraction Joints.

Saw or trowel longitudinal and transverse contraction joints at the dimensions and intervals indicated in the Contract Documents. Use a straight, chalked line or other reference acceptable to the Engineer for guiding the line of the joint. Sawing shall begin as soon as the concrete has sufficiently hardened to allow sawing without tearing or raveling. Sequence the sawing to prevent random cracking. Route random cracks to a minimum depth of one (1) inch and a maximum width of three-eighths ($^3/_8$) inch. Seal or apply curing compound to all contraction joints or routed cracks within twenty-four (24) hours of constructing or routing. Clean the contraction joints and routed cracks immediately before sealing operations. Place joint sealant in the sawed contraction joint and routed cracks to one-fourth (¼) inch below the pavement surface.

(I) Construction Joints.

Construct longitudinal and transverse construction joints to the dimensions indicated in the Contract Documents. Clean construction joints immediately before sealing operations. Place joint sealant in sawed construction joints to one-fourth (¼) inch below the pavement surface.

(J) Requirements for Thickness.

When required by the Engineer, check the thickness of the pavement by coring in accordance with ASTM C174, Standard Test Method for Measuring the Thickness of Concrete Elements Using Drilled Concrete Cores. Divide the PCC slope protection and turndowns into sections of six thousand (6,000) square feet or less for coring. Take a minimum of two (2) cores from each section at locations selected by the Engineer. Deliver the cores to the Engineer for measurement.

(K) Defective or Substandard PCC.

Remove and replace in accordance with the Contract Documents any portion(s) of the PCC placement that contains random cracking, plastic shrinkage cracking, scaling, high spots, depressions, or other defects or

substandard conditions as determined by the Engineer. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

The maximum allowable deviation from plane is one-fourth (¼) inch in any ten (10) foot span. The maximum allowable deviation from the specified elevation is minus zero (-0) plus one-half (+½) inch. The maximum allowable deviation for horizontal alignment is one (1) inch. The maximum allowable deviation for horizontal alignment at tie-in locations is one-half (½) inch.

Remove defective or substandard PCC to the nearest joint in all directions unless otherwise directed by the Engineer. At the discretion of the Engineer, route and seal random cracks or plastic shrinkage cracks in lieu of PCC removal and replacement.

The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

807.04 Measurement and Payment.

The Engineer shall measure PCC slope protection for payment as a single unit defined by the number of square yards of PCC slope protection work constructed and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for all turndowns, preformed joint filler, reinforcing steel, preparation of the slopes and subgrade for the turndowns, back filling and fine grading, forming, placing concrete, control joints, joint filling, disposal of all surplus material, finishing the concrete surfaces; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
PCC Slope Protection	Square Yard

THIS PAGE INTENTIONALLY LEFT BLANK

808 – SLOPE DRAINS

808.01 Description.

This work includes the furnishing, placing, and removing of devices installed at the locations indicated in the Contract Documents or as directed by the Engineer and used to transport water from higher elevations to lower elevations without noticeable erosion.

808.02 Material Requirements.

Temporary slope drains shall consist of pipe, fiber mats, rip rap, plastic sheets, or other materials suitable to control erosion identified in the Contract Documents and acceptable to the Engineer.

808.03 Construction Requirements.

Actual site conditions during construction may alter the location or number of slope drains necessary. The Engineer reserves the right to relocate and increase or decrease the quantity of the slope drains to meet such conditions. Such alterations are not alterations in the details of construction or a change in the scope or character of the work. Before commencing slope drain construction, submit a schedule detailing the construction of all erosion controls required by the Contract Documents. Do not commence work until receiving written approval by the Engineer of such schedule. The Engineer shall resolve any conflict between these requirements and laws, rules, or regulations of other federal, state, or local agencies.

Slope drains required due to Contractor negligence; carelessness; failure to construct temporary berms, dikes, dams, sediment basins; or to install permanent controls as required by the Contract Documents or directed by the Engineer are subsidiary to items for which the Contract provides direct payment.

Construct slope drains at the earliest practicable time as outlined in the approved schedule. At a minimum, construct slope drains as part of grading operations where applicable. Construct earthen shoulder berms at the top of cut and fill sections to channel the water into the slope drain and to prevent collected water from spilling over the edge of the slope. At locations of single direction water flow, locate the slope drain in a sump by constructing an earthen berm ditch block perpendicular to the direction of the water flow on the downstream side of the slope drain. The ditch block shall be of sufficient height to block the flow of water. Do not construct the ditch block at an elevation equal or higher than the earthen shoulder berms.

When directed by the Engineer, protect the inlet to the slope drain by lining the inlet area with rip rap, plastic sheets, or other materials acceptable to the Engineer. Use a pipe coupling acceptable to the Engineer to join multiple

pipe sections. Construct sediment pits as required by the Contract Documents or directed by the Engineer. Sediment pit construction is subsidiary to items for which the Contract provides direct payment.

Remove any temporary slope drains, earthen shoulder, or earthen ditch bocks as directed by the Engineer. The removed materials shall become the property of the Contractor and may be used again at the other temporary locations providing they are in a condition acceptable to the Engineer. Dispose of excess materials at a location acceptable to the Engineer. Grade the area to match the surrounding ground to the satisfaction of the Engineer.

808.04 Measurement and Payment.

When indicated in the Contract Documents, the Engineer shall measure slope drains for payment by the linear foot of slope drain constructed, removed as required, and accepted.

When indicated in the Contract Documents, the Engineer shall measure slope drains for payment by the number of tons of slope drain material placed, removed as required, and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for furnishing all pipe, fittings, and couplings; installation and removal of the slope drain and inlet protection; furnishing and installation of the slope drain materials; constructing the sump, earth shoulder berm and earth berm ditch block; grading the disturbed area after removals; and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Temporary Slope Drains	Linear Foot
Permanent Slope Drains	Linear Foot
Temporary Slope Drains	Ton
Permanent Slope Drains	Ton

809 – ROLLED EROSION CONTROL

809.01 Description.

This work includes furnishing and placing fertilizer, seed, and erosion control blankets upon the completed side slopes, ditch bottoms, or backslopes for temporary or permanent erosion control at the locations indicated in the Contract Documents or as directed by the Engineer. Temporary erosion control systems shall use degradable rolled erosion control products designed to reduce soil erosion and improve vegetation establishment. Permanent erosion control systems shall use non-degradable rolled erosion control products designed for permanent and critical hydraulic applications for which the anticipated discharge velocity or shear stress exceeds the limits of mature, natural vegetation.

809.02 Material Requirements.

(A) General.

Rolled erosion control shall consist of mulch control netting, open weave textiles, erosion control blankets, and turf reinforcement mats. Temporary rolled erosion control shall conform to Table 809.01. Use only turf reinforcement mats for permanent rolled erosion control.

Table 809.01
Temporary Rolled Erosion Control Requirements

Property	Type			
	I	II	III	IV
Typical Functional Longevity, Months	3	12	24	36
Minimum Tensile Strength (Machined Direction), Pounds per foot				
(1V:5H Slope)	5	5	25	---
(1V:4H Slope)	5	5	---	---
(1V:3H Slope)	50	50	---	---
(1V:2H Slope)	75	75	---	---
(1V:1.5H Slope)	---	---	100	---
(1V:1H Slope)	---	---	---	125
Maximum "C" Factor				
(1V:5H Slope)	0.10	0.10	0.10	---
(1V:4H Slope)	0.10	0.10	---	---
(1V:3H Slope)	0.15	0.15	---	---
(1V:2H Slope)	0.20	0.20	---	---
(1V:1.5H Slope)	---	---	0.25	---
(1V:1H Slope)	---	---		0.25
Allowable Shear Stress (1V:5H Slope), Pounds per square foot				
(1V:5H Slope)	0.25	0.25	0.25	---
(1V:4H Slope)	0.50	0.50	---	---
(1V:3H Slope)	1.50	1.50	---	---
(1V:2H Slope)	1.75	1.75	---	---
(1V:1.5H Slope)	---	---	2.00	---
(1V:1H Slope)	---	---	---	2.25

Referenced Test Procedures:

- ASTM D5035, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
- ASTM D6459, Standard Test Method for Determination of Erosion Control Blanket (ECB) Performance in Protecting Hillslopes from Rainfall-Induced Erosion
- ASTM D6460, Standard Test Method for Determination of Erosion Control Blanket (ECB) Performance in Protecting Earthen Channels from Stormwater-Induced Erosion

(B) Fertilizer.

Fertilizer shall be an inorganic product containing sixteen (16) to eighteen (18) percent nitrogen and forty-six (46) to forty-eight (48) percent phosphoric acid in a recognized plant food form. Fertilizer shall comply with the current provisions of the Nebraska Fertilizer Act of 1955. Furnish and deliver fertilizer in standard weight bags or bulk. Provide a fertilizer certification form for every load of bulk fertilizer delivered to the project.

(C) Seed.

All seed origins shall be State of Nebraska or adjoining states unless otherwise approved by the Engineer in writing. Submit a seed tag to the Engineer representing the seed that clearly illustrates the variety, origin, and analysis of the seed for any proposed substitute variety or origin. The Engineer reserves the right to reject substitute varieties or origins for any reason. All seeds must comply with applicable local, state, and federal seed laws. Furnish a certified laboratory analysis of each type and lot of seed proposed for use before delivery to the project. The certified laboratory analysis shall provide all information required by local, state, and federal seed laws. Seed shall be perennial rye grass or crown vetch having a minimum purity as required by Table 809.02.

Table 809.02
Seed Purity

Seed Type	Minimum Purity, %
Perennial Rye Grass	90
Crown Vetch	90

(D) Hay or Straw Blankets.

Hay shall be dry cured native hay, also known as prairie hay. Straw shall be threshed straw of oats, wheat, or rye. The maximum moisture content of the hay or straw shall not exceed twenty (20) percent. Hay or straw shall be free of noxious weeds. Do not use hay or straw in an advanced stage of decomposition. Attach hay or straw at a minimum rate of forty-four-hundredths (0.44) pounds per square yard to photodegradable, polypropylene netting using biodegradable thread. Space the stitching at one and one-half (1½) inches on center. The netting shall have openings sized between two-tenths (0.2) and eight-

tenths (0.8) square inches and a minimum weight of three (3) pounds per one thousand (1,000) square feet.

(E) Burlap Fabric.

Burlap fabric shall be standard weave with a weight of three and six-tenths (3.6) to five (5) ounces per square yard.

(F) Straw and Coconut Mats.

Straw and coconut mats shall consist of seventy (70) percent threshed straw of oats, wheat, or rye and thirty (30) percent coconut coir. The maximum moisture content of the straw and coconut coir shall not exceed twenty (20) percent. Attach the straw and coconut coir at a minimum rate of forty-four-hundredths (0.44) pounds per square yard to photodegradable, polypropylene, or jute netting using biodegradable thread. Space the stitching at one and one-half (1½) inches on center. The netting shall have openings sized between five-eighths ($^5/_8$) and one (1) square inch. The minimum weight of the netting shall be three (3) pounds per one thousand (1,000) square feet for polypropylene netting and nine and three-tenths (9.3) pounds per one thousand (1,000) square feet for jute netting.

(G) Wood Excelsior Blankets.

Wood excelsior blankets shall contain a minimum of eighty (80) percent excelsior fibers that are eight (8) inches or longer. The wood excelsior blanket shall be a uniform thickness with the excelsior fibers evenly distributed over the blanket. Attach the wood excelsior fibers to photodegradable, polypropylene netting using biodegradable thread. Space the stitching at one and one-half (1½) inches on center. The netting shall have a maximum opening of two (2) square inches and an approximate weight of fifteen (15) ounces per square yard.

Wood excelsior blankets shall be smolder-resistant treated using a treatment that is non-leaching, non-toxic to vegetation, and non-toxic and not injurious to human beings and acceptable to the Engineer. Test the leaching resistance in accordance with Federal Specification CCC-T-191B, Method 5830, except that the continuous rate of flow of water to the bottom of the container shall be at the rate of five (5) changes per twenty-four (24) hours. Conduct the smolder resistance test after the leaching test on an air-dried sample. When placing a lit cigarette or similar material on the blanket, the materials shall not flame or smolder for more than a distance of twelve (12) inches from the placement location.

Furnish a copy of manufacturer certified tests to the Engineer for each shipment of wood excelsior blankets. The certified tests shall include smolder resistance test results and a statement that the smolder resistant chemicals present are non-leaching, non-toxic to vegetation, and non-toxic and not injurious to human beings.

(H) Mulch Blankets.

Mulch blankets shall be twelve-hundredths (0.12) to five-tenths (0.5) inches thick and shall consist of threshed straw of oats, wheat, or rye; coconut coir; or wood excelsior fibers. Attach the straw, coconut coir, or wood excelsior fibers to photodegradable, polypropylene netting using biodegradable thread. Space the stitching at one and one-half (1½) inches on center. The netting shall have a minimum of eight (8) ounces per square yard.

(I) Coconut Mats.

Coconut mats shall consist of coconut coir. The maximum moisture content of the coconut coir shall not exceed twenty (20) percent. Attach the coconut coir at a minimum rate of forty-four-hundredths (0.44) pounds per square yard to photodegradable, polypropylene, or jute netting using biodegradable thread. Space the stitching at one and one-half (1½) inches on center. The netting shall have openings sized between five-eighths (⅝) and one (1) square inch. The minimum weight of the netting shall be three (3) pounds per one thousand (1,000) square feet for polypropylene netting and nine and three-tenths (9.3) pounds per one thousand (1,000) square feet for jute netting.

(J) Synthetic Mats.

Synthetic mats shall be green in color and consist of polyolefin monofilament fibers positioned between and attached to two (2) polypropylene nets using polyolefin thread. The mat shall meet the requirements of Table 809.03. Determine compliance with the minimum strength requirements in the machined and cross-machined direction under dry or saturated conditions. Determine porosity based upon mass, thickness, and specific gravity. Determine resiliency based upon the percentage of the original thickness retained thirty (30) minutes after applying three (3) load cycles. A load cycle shall consist of applying a one hundred (100) pounds per square inch load for sixty (60) seconds followed by sixty (60) seconds without a load. Measure ultraviolet stability based upon the tensile strength retained after one thousand (1000) hours in a Xenon Arc Weatherometer.

Table 809.03
Synthetic Mat Requirements

Property	Requirement
Minimum Thickness, Inch	0.25
Minimum Tensile Strength (Machined Direction), Pounds per foot	108
Minimum Tensile Strength (Cross-machined Direction), Pounds per foot	36
Maximum Elongation, %	50
Minimum Porosity, %	85
Resiliency, %	80
Ultraviolet Stability	80

Referenced Test Procedures:

- ASTM D1777, Standard Test Method for Thickness of Textile Materials

- ASTM D4355, Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
- ASTM D5035, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)

(K) Synthetic Mesh.

Synthetic mesh shall be beige in color and consist of polypropylene fibers spun in the same direction and woven to form a geotextile mesh. Synthetic mesh shall meet the requirements of Table 809.04.

Table 809.04
Synthetic Mesh Requirements

Property	Requirement
Minimum Mass, Ounces per square yard	1.74
Minimum Tensile Strength (Machined Direction), Pounds per foot	460
Minimum Tensile Strength (Cross-machined Direction), Pounds per foot	250
Maximum Elongation at Break, %	40

Referenced Test Procedures:

- ASTM D5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles
- ASTM D5035, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)

(L) Turf Reinforcement Mats.

Turf reinforcement mats shall be black in color and consist of entangled polymer netting, monofilaments, or fibers bonded using polymer welding, thermal or polymer fusion, or positioning between and attaching to two (2) non-biodegradable polypropylene nets using polyolefin thread. Treat turf reinforcement mats to resist biological, chemical, and ultraviolet degradation. Turf reinforcement mats shall conform to the requirements of Table 809.05. Determine compliance with the minimum strength requirements in the machined and cross-machined direction under dry or saturated conditions. Determine porosity based upon mass, thickness, and specific gravity. Measure ultraviolet stability based upon the tensile strength retained after one thousand (1,000) hours in a Xenon Arc Weatherometer. Determine the allowable shear stress only on the non-degradable portions of the turf reinforcement mat alone.

Table 809.05
Turf Reinforcement Mat Requirements

Property	Requirement
Minimum Thickness, Inch	0.50
Minimum Tensile Strength (Machined Direction), Pounds per foot	
(1V:5H Slope)	125
(1V:4H Slope)	150
(1V:3H Slope)	175
Minimum Tensile Strength (Cross-machined Direction), Pounds per foot	54
Maximum Elongation, Percent	90
Minimum Porosity, Percent	80
Resiliency, Percent	80
Ultraviolet Stability	80
Allowable Shear Stress, Pounds per square foot	
(1V:5H Slope)	6
(1V:4H Slope)	8
(1V:3H Slope)	10

Referenced Test Procedures:

- ASTM D1777, Standard Test Method for Thickness of Textile Materials
- ASTM D4355, Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
- ASTM D5035, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
- ASTM D6524, Standard Test Method for Measuring the Resiliency of Turf Reinforcement Mats (TRMs)

(M) Wire Staples.

Wire staples shall be made of No. 11 gauge steel wire having a minimum length of six (6) inches. For installations in sand or sandy soils, wire staples shall have a minimum length of twelve (12) inches.

809.03 Construction Requirements.

(A) General.

Perform the work immediately after completing the finish grading operations. Notify the Engineer a minimum of forty-eight (48) hours before commencing the work. Do not proceed with such work until authorized by the Engineer. No restrictive seeding periods shall apply to this work. Do not perform seeding or fertilizing operations if the ground is wet, frozen, or otherwise untillable. Do not perform seeding or fertilizing operations when conditions do not allow for a uniform distribution of materials.

The areas receiving rolled erosion control shall be in a smooth, even condition, free of all debris, roots, and stones larger than one (1) inch in diameter. Pulverize, rake out, or remove all lumps of soil. Remove all vegetation from these areas except for the desirable native vegetation

that the Contract Documents or the Engineer designates to remain undisturbed. The soil in the areas to be protected shall be loosened to a depth of not less than one (1) inch by disking, harrowing, raking, or other approved methods. Tamp fill earth and shape ditches to the lines and grades indicated in the Contract Documents or directed by the Engineer. Prepare the seedbed by scarifying the upper two (2) inches of the soil in a manner acceptable to the Engineer a maximum of five (5) days before the sowing of seed. Perform disking, harrowing, and raking in the longitudinal direction on all slopes steeper than 1V:4H.

(B) Fertilizing.

Using an approved mechanical spreader or hydraulic seeder, apply fertilizer uniformly over all areas receiving seed. Apply available nitrogen (N_2) at a rate of nine (9) pounds per one thousand (1,000) square yards. Apply phosphoric acid (P_2O_5) at a rate of twenty-four (24) pounds per one thousand (1,000) square yards. The Engineer reserves the right to alter the mixing proportions or application rates to meet site conditions. Do not blend any fertilizer without the Engineer present. Incorporate fertilizers into the soil before seeding.

(C) Seed Application.

Apply seed after fertilizing using approved mechanical power-drawn drills equipped with press wheels or drag chains, broadcast-type seeders, or hydraulic seeders. Using a standard lawn roller, harrow or hand rake and compact any areas seeded using a broadcast-type seeder or hydraulic seeder. Apply seed in accordance with Table 809.06.

Table 809.06
Seed Application Rates

Seed Type	Application Rate Pounds of Pure Live Seed per 1000 Square Yards
Perennial Rye Grass	50
Crown Vetch	30

Maintain a planting depth of one-half (½) to three-fourths (¾) inches when using a mechanical power-drawn drill.

(D) Rolled Erosion Control Installation.

Immediately after seeding or turf establishment, place the rolled erosion control in accordance with the Contract Documents, the manufacturer's recommendations, or as directed by the Engineer. Install the erosion control blanket flat and parallel to the flow of water without stretching. Overlap adjacent and subsequent rolled erosion control in accordance with the manufacturer's recommendations but not less than three (3) inches for adjacent sections or twelve (12) inches for subsequent sections. Overlap with the downhill and the upslope sections always on top. Anchor the erosion control blanket using wire staples after placing the erosion control blanket. Space the staples three (3) to four (4) feet apart in three (3) rows along each strip, with one (1) row along each edge, and one (1) row alternately spaced in the center.

Use one (1) additional row of staples for backslope and ditch intersection lines. Space staples a maximum of nine (9) inches apart across the width for all ditch anchor folds, splice joints, top of slope anchor folds, and terminations.

Excavate a six (6) inch vertical slot at the top of the slope. Extend the upslope terminal end of the rolled erosion control a minimum of thirty (30) inches past the vertical slot. Place the upper edge of the last upslope section in a six (6) inch vertical slot. Anchor the rolled erosion control material in the slot using staples placed at twelve (12) inch or less intervals. Backfill and compact the slot using soil to anchor the upper portion of the rolled erosion control. Lightly seed the backfill and cover with the rolled erosion control that extends beyond the slot. Staple the overlapped portion downslope from the vertical trench using staples placed at twelve (12) inch or less intervals. Bury the upstream terminal end of the rolled erosion control as directed by the Engineer. Anchor all other sections of the rolled erosion control in accordance with the manufacturer's recommendations but not less than two (2) staples per square yard.

When directed by the Engineer, lightly seed and rake topsoil across the top of the rolled erosion control to fill any voids in the matting.

809.04 Measurement and Payment.

The Engineer shall measure rolled erosion control for payment as a single unit defined as the number of square yards measured in-place along the slopes and ditch bottoms furnished, installed, and accepted.

Excess material required to satisfy overlap requirements is subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for furnishing, loading, hauling, and applying all materials including seed, fertilizer, erosion control blanket, and anchoring; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Rolled Erosion Control, Type ___	Square Yard

810 – TEMPORARY EROSION AND POLLUTION CONTROLS

810.01 Description.

This work includes furnishing and constructing temporary erosion and water pollution controls including silt fence, berms, dikes, dams, sediment basins, temporary slope drains, and other temporary erosion control devices, methods, or necessary appurtenances at the locations indicated in the Contract Documents or as directed by the Engineer. Temporary controls may include work outside of the Right-of-Way.

Temporary pollution control measures will be used to correct conditions that develop during construction that were not foreseen during the design stage; that are needed prior to installation of permanent pollution control features; or that are needed temporarily to control erosion that develops during normal construction practices but are not associated with permanent control features on the project.

810.02 Material Requirements.

(A) Silt Fence Material.
Silt fence material shall conform to the requirements of ASTM D6461, Standard Specification for Silt Fence Materials.

(B) Posts.
Posts shall be wood, steel, or synthetic posts a minimum of sixty (60) inches in length, and shall conform to the requirements of ASTM D6461, Standard Specification for Silt Fence Materials. Hardwood posts shall have a square cross section with a minimum cross sectional area of one and forty-four hundredths (1.44) square inches. No. 2 Southern Pine posts shall have a square cross section with a minimum cross sectional area of six and twenty-five hundredths (6.25) square inches. Steel posts shall be UTL- or C-shaped with a minimum weight of one and three-tenths (1.3) pounds per linear foot.

(C) Support Fence.
Support fence shall be wire or polymeric mesh material and shall conform to the requirements of ASTM D6461, Standard Specification for Silt Fence Materials. Wire support fence shall use fourteen (14) gauge wire and shall have a minimum of six (6) horizontal strands. Space vertical strands a maximum of six (6) inches apart.

(D) Hay Bales.
Hay or straw mulch shall be dry cured native hay, also known as prairie hay, or threshed grain straw. Do not use hay or straw mulch in an advanced stage of decomposition. Hay bales shall be a minimum of fourteen (14) inches high, eighteen (18) inches wide, and thirty-six (36) inches long.

(E) Temporary Silt Dikes.

Temporary silt dikes shall be triangular-shaped. The center shall have a minimum height of eight (8) inches. The sides shall be of equal length. The base shall have a minimum width of sixteen (16) inches. The minimum length shall be seven feet (7) unless otherwise indicated in the Contract Documents. The triangular-shaped inner material shall be urethane foam. The outer cover shall be a woven silt fence material conforming to the requirements of ASTM D6461, Standard Specification for Silt Fence Materials. Install the silt fence material around the inner material. The silt fence material shall extend a minimum of two (2) feet beyond both sides of the triangle.

(F) Wire Staples.

Wire staples shall be made of No. 11 gauge steel wire having a minimum length of six (6) inches.

(G) Granular Inlet Filter Fabric.

Gravel curb inlet filter fabric shall be a sheet or tube comprised of a woven silt fence material conforming to the requirements of ASTM D6461, Standard Specification for Silt Fence Materials. The fabric shall have sufficient strength to withstand the puncture or wear from the filter aggregate. Dimension tube gravel curb inlet filters to be a minimum of nine (9) inches in diameter. The length shall be a minimum of two (2) feet longer than the curb inlet opening. Dimension sheet gravel curb inlet filters to be a minimum of three feet wide and to extend two (2) feet beyond each end of the curb inlet.

(H) Hay Inlet Filters.

Hay or straw mulch shall be dry cured native hay, also known as prairie hay, or threshed grain straw. Do not use hay or straw mulch in an advanced stage of decomposition. The outer cover shall be a woven silt fence material conforming to the requirements of ASTM D6461, Standard Specification for Silt Fence Materials. Dimension the hay curb inlet filters to be a minimum of nine (9) inches in diameter. The length shall be a minimum of two (2) feet longer than the curb inlet opening.

(I) Pre-Fabricated Area Inlet Filters.

Pre-fabricated area inlet filters shall consist of a round or square, rigid frame sized to match the area inlet. The outer cover shall be a woven silt fence material conforming to the requirements of ASTM D6461, Standard Specification for Silt Fence Materials.

(J) Filter Aggregate.

Filter aggregate shall meet the requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates.

(K) Temporary Berm Material.

Temporary berm material shall consist of silty clay (CL-ML) or lean clay (CL) materials as determined in accordance with ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes. Borrow material shall be free of debris, vegetation, or organic matter. The Engineer must approve all material before use by the Contractor.

810.03 Construction Requirements.

(A) General.

Actual site conditions during construction may alter the location or number of temporary erosion and pollution controls necessary. The Engineer reserves the right to relocate and increase or decrease the quantity of the temporary erosion and pollution controls to meet such conditions. Such alterations are not alterations in the details of construction or a change in the scope or character of the work. Coordinate temporary erosion and pollution controls with the installation of permanent erosion and pollution controls to assure economical, effective, and continuous erosion control throughout the construction period. Before commencing temporary erosion and pollution control construction, submit a schedule detailing the construction of all erosion controls required by the Contract Documents. Include details on erosion and pollution controls for haul roads as required by the Engineer. Incorporate all permanent erosion control features into the project at the earliest practicable time. Do not commence work until receiving written approval by the Engineer of such schedule. The Engineer shall resolve any conflict between these requirements and laws, rules, or regulations of other federal, state, or local agencies.

Inspect all temporary erosion and pollution controls after each rainfall event of one-half (½) inch or greater. Repair any deficient or damaged controls. Remove any accumulated silt or debris as directed by the Engineer. Replace any temporary erosion or pollution control damaged or inadvertently moved during the removal process. Dispose of the removed materials in a manner acceptable to the Engineer.

Perform any erosion control work resulting from Contractor negligence, carelessness, or failure to construct temporary berms, dikes, dams, sediment basins; or to install permanent controls as a part of the work at no additional cost to the City.

(B) Silt Fence Installation.

The Contractor shall install silt fence and related materials in accordance with ASTM D6462, Standard Practice for Silt Fence Installation.

(C) Hay Bale Installation.
Excavate an eight (8) inch deep trench along the line indicated for hay bale construction. Place bales along the trench with the ends tightly abutted. Secure the bales by driving two (2) stakes through the bale, one angled through the previously placed, abutting bale, the other vertically through the bale. Drive the stakes flush with the top of the bale.

(D) Pre-fabricated Temporary Silt Dike Installation.
Install pre-fabricated temporary silt dikes using wire staples or other methods as directed by the silt dike manufacturer.

(E) Tubular Granular or Hay Curb Inlet Filters.
Place the tubular curb inlet filter in accordance with the manufacturer's recommendations and in such a manner that the filter extends a minimum of one (1) foot beyond the edges of the inlet opening along the gutter line.

(F) Pre-fabricated Area Inlet Filter Installation.
Excavate to approximately six (6) inches below the top of the inlet structure and a sufficient area around the area inlet structure to permit installation of the pre-fabricated area inlet filter. Place the frame on the inlet structure and install the filter in accordance with the manufacturer's instructions. Backfill around the base of the inlet filter using filter aggregate. The filter aggregate shall extend a minimum of six (6) inches above the base of the filter frame. Place a soil cap on the filter aggregate as directed by the Engineer.

Remove accumulated material when the height of the accumulated material exceeds sixty-five (65) percent of the total height of the inlet filter frame. Remove, clean, and inspect the filter. Replace damaged filters with new filters. Reinstall filters as directed above.

(G) Temporary Berm and Dike Construction.
Construct temporary berms and dikes at the locations indicated in the Contract Documents or as directed by the Engineer. Provide borrow material unless otherwise directed by the Contract Documents. The Contractor may use suitable and available excavation materials before using borrow excavation. Do not obtain borrow material from any location on the project that is not identified as a borrow area in the Contract Documents or by the Engineer. The Engineer must approve all off-site borrow materials before use. The Contractor is responsible for arranging and paying all costs associated with obtaining a sufficient amount of borrow material.

Construct temporary berms and dikes using materials acceptable to the Engineer. Remove all organic matter from the underlying ground before beginning temporary berm construction. Place temporary berm and dike materials in uniform horizontal layers not exceeding eight (8)

inches loose lift thickness. Construct each layer to the specified density before placing additional layers. Level each layer before commencing compaction efforts. Adjust the moisture content as necessary to fulfill moisture requirements. The Engineer reserves the right to alter the thickness of the lifts to meet the specific conditions of the project site. Place successive lifts in a manner that does not significantly alter the moisture content or density of previously completed lifts. Construct the first layers of embankment materials over soft, saturated ground using light, tracked equipment and lift thickness acceptable to the Engineer.

Compact temporary berms and dikes to a minimum of ninety-five (95) percent of the maximum dry density. Maintain the moisture content between minus three (-3) and plus five (+5) percent of the optimum moisture. The maximum dry density and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort. Grade the temporary berm surfaces to be smooth and uniform. The final elevation of temporary berms and dikes shall be within three (3) inches of the design elevation.

(H) Area Inlet and Curb Inlet Protection.

Protect any area inlets and curb inlets identified in the Contract Documents or by the Engineer. Use methods and materials acceptable to the Engineer. Remove accumulated material as necessary or as required by the Engineer.

810.04 Measurement and Payment.

The Engineer shall measure silt fence for payment as a single unit defined as the number of linear feet of silt fence supplied, installed, and accepted.

The Engineer shall measure hay bale silt checks for payment as a single unit defined as the number of linear feet of hay bale silt check supplied, installed, and accepted.

The Engineer shall measure pre-fabricated temporary silt dikes for payment as a single unit defined as the number of linear feet of pre-fabricated temporary silt dike supplied, installed, and accepted.

The Engineer shall measure tubular curb inlet filters for payment as a single unit defined as the number of linear feet of tubular curb inlet filter supplied, installed, and accepted.

The Engineer shall measure pre-fabricated area inlet filters for payment as a single unit defined by the number of pre-fabricated area inlet filters supplied, installed, and accepted.

Temporary berms and dikes constructed within the normal limits of construction or at the end of ditch cut sections and indicated in the Contract Documents are subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure area inlet protection for payment as a single unit defined by the number of area inlets protected and accepted.

The Engineer shall measure curb inlet protection for payment as a single unit defined by the number of curb inlets protected and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This contract price shall be full compensation for supplying and installing all silt fence, hay bales, dikes, berms, filters, hay, straw, filter aggregate, stakes, and binding materials; and furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Silt Fence	Linear Foot
Hay Bale Silt Check	Linear Foot
Pre-fabricated Temporary Silt Dike	Linear Foot
Tubular Curb Inlet Filter	Linear Foot
Pre-fabricated Area Inlet Filter	Each
Area Inlet Protection	Each
Curb Inlet Protection	Each

811 – ARTICULATED BLOCK EROSION CONTROL

811.01 Description.

This work includes supplying and installing articulated block mats for erosion control using an assembly comprised of pre-manufactured PCC blocks bound into mats using revetment cables and having specific hydraulic capabilities.

811.02 Material Requirements.

All articulated block mats and component materials shall meet the requirements of ASTM D6684, Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Revetment Systems. Design the articulated block mats for simultaneous lifting of both ends. Select the type of cable, fittings, and splices using a minimum factor of safety of three (3) and accounting for any bending of the cables around hooks or pins during lifting. The mats shall have a minimum flex in the uplift direction of twenty-five (25) degrees and a minimum flex in the downward direction of forty-five (45) degrees between any given row or column of blocks. Provide the Engineer access to all manufacturing facilities during production of the articulated block mats. Furnish the Engineer with all manufacturer specifications, literature, performance data, design calculations, shop drawings, and certificates of compliance for the articulated block mats, block, revetment cable, and revetment cable fittings and connectors before assembling the articulated block mats.

Articulated block shall have a maximum freeze-thaw weight loss of ten (10) percent after twenty-five (25) cycles as determined by ASTM C1262, Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units. Test the freeze-thaw durability using a non-saline water solution. Replace any articulated block containing cracks wider than one-fourth (¼) inch, cracks deeper than one (1) inch, or chipping resulting in a weight loss of ten (10) percent.

811.03 Construction Requirements.

Grade and compact areas to receive articulated block mats to the lines, grades, and tolerances required by the Contract Documents or as directed by the Engineer. Compact areas to a minimum of ninety-five (95) percent of the maximum dry density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort. Slopes shall be a smooth plane surface. Re-grade or remove all slope deformities, roots, grade stakes, and stones which project normal to the local slope face and any holes, equipment tracks, or other voids deeper than one (1) inch and normal to the slope face. Re-grade any grooves or depressions greater than one-half (½) inch in depth and normal to the slope

face with a dimension exceeding twelve (12) inches in any direction. Excavate and prepare anchor trenches, side trenches, and toe trenches or aprons in accordance with the articulated block mat manufacturer's recommendations. Grade the width and length of the anchor trench hinge-point at the top of the slope to eliminate any depressions or bumps. Grading and compacting areas to receive articulated block mats is subsidiary to items for which the Contract provides direct payment.

Place the geotextile filter fabric directly on the prepared area free of folds or wrinkles. Do not disturb the fabric after placement. Place adjacent strips of geotextile filter fabric so that the upstream or upslope strips overlap the downstream or downslope strips. Overlap dimensions shall meet the requirements of the geotextile manufacturer. Extend the geotextile filter fabric a minimum of one (1) foot beyond the top and bottom revetment termination points. Do not position the top lap edge of the geotextile filter fabric at the same location as a space between adjacent articulated block mats. If such positioning is unavoidable, fill the gap between the articulated block mats with PCC in a manner acceptable to the Engineer.

Provide a representative of the articulated block mat manufacturer employed by the articulated block mat manufacturer during all stages of assembly and placement of the articulated block mat. Assemble articulated block mats in accordance with ASTM D6684, Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Revetment Systems. Install the articulated block or articulated block mat using the same techniques that were used during testing for determining the design factors and related performance data. Place the articulated blocks on the filter fabric in such a manner as to produce a smooth plane surface. Seat the articulated block mats using a smooth steel drum roller or other means acceptable to the Engineer. Repair or replace any individual block that protrudes more than one-half (½) inch above the plane of the articulated block mat or that has an open area greater than ten (10) percent of the individual block surface. Repair or replace any individual block that has an interlocking surface that protrudes beyond the perimeter of the blocks and reduces the flexibility or articulation capability or that is damaged or broken during shipment or placement. Position pre-assembled sections using equipment and techniques designed for the intended use, having sufficient capacity, and acceptable to the Engineer. Place the mats abutting to adjacent mats without bumping, dragging, tearing, or otherwise damaging the underlying geotextile filter fabric. Fill any mat seams or openings between mats greater than two (2) inches or any seams resulting from a discontinuous revetment surface due to changes in grade with PCC when directed by the Engineer.

Backfill and compact anchor, toe, and side trenches flush with the top of the blocks or as indicated in the Contract Documents. Backfill and compact the cells or openings in the articulated block mat using soil or other materials acceptable to the Engineer to eliminate any voids between the geotextile filter fabric and one (1) inch above the articulated block mat surface.

Compact the backfill to a minimum of ninety-five (95) percent of the maximum dry density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort. Complete backfilling and compacting operations in a timely fashion to prevent undermining of the articulated block mat system before final acceptance. Remove, re-grade, and replace any articulated block mat system undermined before final acceptance at no additional cost to the City.

811.04 Measurement and Payment.

The Engineer shall measure the articulated block erosion control for payment as a single unit defined by the number of square yards of articulated block erosion control supplied, constructed, and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This contract price shall be full compensation for supplying and installing all articulated block, revetment cable, fittings, connections, geotextile filter fabric, and backfill materials; and for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Articulated Block Erosion Control	Square Yard

THIS PAGE INTENTIONALLY LEFT BLANK

812 – GABION BASKETS AND REVET MATTRESSES

812.01 Description.

This work includes furnishing, assembling, tying, and filling with approved stones, wire mesh gabion baskets, or revet mattresses constructed and placed along the lines, grades, dimensions, and details indicated in the Contract Documents or as directed by the Engineer.

812.02 Material Requirements.

(A) Basket and Mattress Fill Material.

Fill material for gabion baskets or revet mattresses shall be sandstone, limestone, quartzite, or broken PCC free of earth, clay, or refuse that does not disintegrate under action of air or water. Obtain fill materials from sources acceptable to the Engineer. Evaluate aggregate and broken PCC in accordance with ASTM D4992, Standard Practice for Evaluation of Rock to be Used for Erosion Control. Perform petrographic analysis only when requested by the Engineer. Use the same type of fill material for all baskets, not a combination of one (1) or more fill materials. When measured in any direction, the fill material for gabion baskets shall have a maximum size of eight (8) inches and a minimum size of four (4) inches with the a minimum of fifty (50) percent of the material sized between five (5) and six (6) inches. When measured in any direction, the fill material for revet mattresses shall have a maximum size of four (4) inches and a minimum size of three (3) inches.

Fill material for gabion baskets or revet mattresses shall conform to the requirements of Table 812.01. The Engineer reserves the right to accept past testing and service records to determine the acceptability of quarry aggregate. Ship the fill material in a manner that avoids segregation. The fill material shall be angular in shape to permit interlocking between the various rock sizes. Do not use fill material containing more than ten (10) percent flat pieces having a length to height ratio of greater than five (5) to one (1) (5:1). Size broken PCC by pulverizing slabs of PCC removed from the project or other projects.

Table 812.01

Physical Property Requirements

Physical Property	Acceptable Range
Sodium Sulfate Soundness, (5 cycles)*	10.0% max. loss
Magnesium Sulfate Soundness, (5 cycles)*	15.0% max. loss
Freeze-Thaw Soundness, (25 cycles)*	15.0% max. loss
LA Abrasion, ASTM C131 and ASTM D535	40.0% max. loss
Bulk Specific Gravity	2.40 min.
Absorption, ASTM C127 and ASTM C128	3.0% max.

*Only one of the three soundness requirements must be fulfilled.

(B) Geotextile Fabric.
Geotextile fabric shall meet the requirements for a Class 1, geotextile fabric as defined by AASHTO M288, Geotextile Specification for Highway Applications for the type and use indicated in the Contract Documents.

(C) Wire Mesh Baskets.
Wire mesh baskets shall conform to the requirements of ASTM A974, Standard Specification for Welded Wire Fabric Gabions and Gabion Mattresses (Metallic-Coated or Polyvinyl Chloride (PVC) Coated). Double-twisted hexagonal mesh baskets shall conform to ASTM A975, Standard Specification for Double-Twisted Hexagonal Mesh Gabions and Revet Mattresses (Metallic-Coated Steel Wire or Metallic-Coated Steel Wire With Poly(Vinyl Chloride) (PVC) Coating). Coat all wire with a zinc coating followed by a polyvinyl chloride coating.

812.03 Construction Requirements.

Grade and compact areas to receive gabion mattresses or revet mattresses to the lines, grades, and tolerances required by the Contract Documents or as directed by the Engineer. Compact areas to a minimum of ninety-five (95) percent of the maximum dry density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort. Slopes shall be a smooth plane surface. Re-grade or remove all slope deformities, roots, grade stakes, and stones which project normal to the local slope face and any holes, equipment tracks, or other voids deeper than one (1) inch and normal to the slope face. Re-grade any grooves or depressions greater than one (1) inch in depth and normal to the slope face with a dimension exceeding twelve (12) inches in any direction. Grading and compacting areas to receive articulated block mats is subsidiary to items for which the Contract provides direct payment.

Remove all kinks and bends from the unassembled gabion baskets or revet mattresses before assembly. Assemble each unit individually by erecting the sides, ends and diaphragm(s) ensuring that all creases are in the correct position and the tops of all sides are level. Connect the four corners of the unit first. Connect the edge wires of internal diaphragm(s) to the sides on gabion baskets. Overlap the mesh at the corners and connect the edges of internal diaphragms to the sides for revet mattresses. Use lacing wire or stainless steel fasteners for all connections. Secure the lacing wire to the base of the connection by looping and twisting then proceed to lace with alternating single and double loops every other mesh opening and securely fasten to the top of the connection. Cut a sufficient length of lacing wire to avoid splicing the lacing wire during the connection. Install fasteners and additional connections in accordance with the manufacturer's recommendations. The maximum spacing between fasteners shall be six (6) inches.

Place the assembled baskets or mattresses at the location indicated in the Contract Documents or directed by the Engineer without damaging or otherwise altering the shape of the baskets or mattresses. Secure abutting baskets in all directions using lacing wire connected using the same procedures required for connecting the sides, ends, and diaphragms. Cut, fold, and connect any surplus mesh from custom-sized baskets to an adjacent gabion basket face. Secure the surplus material and the cut edges using lacing wire connected using the same procedures required for connecting the sides, ends, and diaphragms. Fill lower tier baskets before placing and securing upper tier baskets.

Fill the gabion baskets or revet mattresses with fill material in a manner that maintains the required alignment, avoids bulges, minimizes the amount of internal voids, and avoids damaging the PVC coating on the wires. Place fill material in a maximum lift thickness of one (1) foot. Fill adjacent baskets and mattresses simultaneously. Hand place all fill material on the exposed faces of the gabion baskets or revet mattresses to provide a tight, neat, aesthetic appearance acceptable to the Engineer. Overfill the basket or mattress approximately two (2) inches above the sides before closing the lid. Secure the lid to the sides, ends, and diaphragms using lacing wire or stainless steel fasteners connected using the same procedures required for connecting the sides, ends, and diaphragms. Bend all projections or wire ends toward the center of the basket or mattress.

Backfill and compact gabion baskets flush with the top of each tier using soil or other materials acceptable to the Engineer before placing the next successive tier. Backfill and compact revet mattresses flush with the top of the mattress using soil or other materials acceptable to the Engineer. Compact the backfill to a minimum of ninety-five (95) percent of the maximum dry density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

812.04 Measurement and Payment.

The Engineer shall measure gabion baskets for payment as a single unit defined by the number of cubic yards of gabion baskets supplied, constructed, and accepted.

The Engineer shall measure revet mattresses for payment as a single unit defined by the number of cubic yards of revet mattresses supplied, constructed, and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This contract price shall be full compensation for supplying, assembling, and placing all baskets and mattresses; furnishing and placing all fill material; backfilling; and for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Gabion Basket	Cubic Yard
Revet Mattress	Cubic Yard

813 – FENCE

813.01 Description.

This work includes furnishing of materials for and the erection of chain-link fence, including takedown panels, gates, private fence terminals, concrete foundations, and other appurtenances, at the locations indicated in the Contract Documents or as directed by the Engineer. Fences shall be metal chain link, coated metal chain link, wood, or rigid PVC. All fence fabric furnished under the contract shall be of the same type. Tie wires shall be either zinc-coated steel tie wire, aluminum-coated steel tie wire, or aluminum alloy tie wire. All tie wire furnished under the contract shall be of the same type.

813.02 Material Requirements.

(A) Metal Chain Link Fence Materials.

Metal chain link fence materials shall conform to the applicable sections of the following:

- ASTM A116, Standard Specification for Metallic-Coated, Steel Woven Wire Fence Fabric
- ASTM A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
- ASTM A491, Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric
- ASTM A584, Standard Specification for Aluminum-Coated Steel Woven Wire Fence Fabric
- ASTM A585, Standard Specification for Aluminum-Coated Steel Barbed Wire
- ASTM A702, Standard Specification for Steel Fence Posts and Assemblies, Hot Wrought
- ASTM A817, Standard Specification for Metallic-Coated Steel Wire for Chain-Link Fence Fabric and Marcelled Tension Wire
- ASTM A824, Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use With Chain Link Fence
- ASTM A854, Standard Specification for Metallic-Coated Steel Smooth High-Tensile Fence and Trellis Wire
- ASTM B429, Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube
- ASTM F626, Standard Specification for Fence Fittings
- ASTM F654, Standard Specification for Residential Chain Link Fence Gates
- ASTM F668, Standard Specification for Poly(Vinyl Chloride) (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric

- ASTM F761, Standard Specification for Strength Requirements of Steel Posts and Rails for Residential Chain-Link Fence
- ASTM F900, Standard Specification for Industrial and Commercial Swing Gates
- ASTM F934, Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials
- ASTM F1043, Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework
- ASTM F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
- ASTM F1183, Standard Specification for Aluminum Alloy Chain Link Fence Fabric
- ASTM F1184, Standard Specification for Industrial and Commercial Horizontal Slide Gates
- ASTM F1345, Standard Specification for Zinc-5% Aluminum-Mischmetal Alloy-Coated Steel Chain-Link Fence Fabric
- ASTM F1664, Standard Specification for Poly(Vinyl Chloride) (PVC)-Coated Steel Tension Wire Used with Chain-Link Fence
- ASTM F1665, Standard Specification for Poly(Vinyl Chloride) (PVC)and Other Conforming Organic Polymer-Coated Steel Barbed Wire Used With Chain-Link Fence
- ASTM F1712, Standard Specification for Steel Chain-Link Fencing Materials Used in Detention and Correctional Facilities

Chain link fabric shall be woven in a two (2) inch diamond mesh. The top selvage shall be twisted and barbed and the bottom selvage shall be twisted and barbed or knuckled. Gate fabric shall be of the same type, size of mesh, gauge size of wire and selvage as that specified for fence. Latches, hinges, stops, and gatekeepers shall be galvanized steel. Single gate latches shall be fork type, gravity drop bar type with positive locking features, or plunger bar type of full gate height. Provide gatekeepers for each gate leaf over five (5) feet wide. Gatekeepers shall consist of a mechanical device for securing the free end of the gate when in full open position. Gate hinges shall be of adequate strength for the gate, have large bearing surfaces for clamping or bolting in position, and shall allow easy opening and closing by one (1) person. Hinges shall allow the gate leaf to swing a minimum of one hundred eighty (180) degrees.

(B) Wood Fence Materials.

Wood fence materials shall conform to the requirements of ASTM F537, Standard Specification for Design, Fabrication, and Installation of Fences Constructed of Wood and Related Materials.

(C) PVC Fence Materials.
PVC fence materials shall conform to the requirements of ASTM F964, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Exterior Profiles Used for Fencing.

(D) Portland Cement for PCC.
Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3.

(E) Water for PCC.
All water used in the concrete mixture shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(F) Aggregate for PCC.
Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(G) Admixtures for PCC.
Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Pozzolanic admixtures shall be fly ash or raw or calcined natural pozzolans meeting the requirements of ASTM C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC. Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(H) PCC Mix Proportioning.

Proportion PCC mixtures to meet the requirements of Table 813.01.

Table 813.01
PCC Properties

Mix Type	L6
Portland Cement Content, lbs. per cubic yard	564
Coarse Aggregate, % of Total Aggregate	30±3
Fine Aggregate, % of Total Aggregate	70±3
Maximum Water Cement Ratio	0.45
Minimum 28-Day Compressive Strength, psi	3500
Air Content, %	6.5±1.0
Slump, inches	4-inch Max.
Concrete Temperature during placement, °F	70±25

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(I) Reinforcing Steel for PCC.

Reinforcing steel shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

(J) Pre-molded Joint Filler.

Pre-molded joint filler for expansion joints shall conform to the requirements of ASTM D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). Neatly punch holes to admit the dowels where indicated in the Contract Documents. The diameter of the holes shall not exceed one-half (½) inch greater than the bar diameter. When more than one piece is required for a joint, securely fasten the abutting ends by stapling or other positive fastening means satisfactory to the Engineer.

(K) Curing Materials for PCC.

Curing materials shall be membrane-forming compounds or polyethylene film. Liquid membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

(L) Copper Grounding Wire and Grounding Rod.

Copper grounding wire shall be No. 6 AWG stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire. Grounding rods and test stakes shall comply with IMSA Specification Number 62-1956 excluding length and diameter requirements. Ground rods and test stakes shall have a minimum diameter of five-eighths ($^5/_8$) inch. Supply ground rods and test stakes with a ground rod clamp.

(M) Bollards.

Bollards shall be wood or PCC-filled metal poles dimensioned as indicated in the Contract Documents and acceptable to the Engineer.

813.03 Construction Requirements.

(A) General.

Confine all operations to areas within the Right-of-Way or easement limits. Install fences neatly and in a competent manner using tools and equipment designed for the proposed use. Accomplish all work using technicians skilled in the proposed work and acceptable to the Engineer. Upon request of the Engineer, furnish samples and/or mill certificates for each component confirming compliance with the Contract Documents. Remove and replace any non-conforming work or materials at no additional cost to the City. Remove all excess materials and equipment; dispose of all excess excavated material; correct any damage to the completed fence, slopes, ditches, or shoulders; and leave all work in a neat and presentable condition upon completion of the work.

Grade the fence line to remove irregular projections or depressions and allow the fence to conform to the general contour of the ground. Limit grading operations to within two (2) feet of the fence line unless otherwise directed by the Contract Documents or the Engineer. Perform grading operations with minimum disturbance to the terrain outside the fence line.

Attach fencing materials on the street side of the posts unless otherwise directed by the Contract Documents or the Engineer. When constructing fence parallel to Right-of-Way lines, erect the fence posts centered on the Right-of-Way line or as directed by the Engineer. Install fence posts plumb and true to lines and grades indicated in the

Contract Documents or as directed by the Engineer. Set tops of posts to required grade and alignment. Adjust post spacing at fence breaks or at intersections with existing fences to meet the specified closure. Embed fence posts set in earth in PCC footings. Embed fence posts set in or behind retaining walls or other structures in the structure at the time of construction or embed metal sleeve of sufficient diameter to allow subsequent placement of the fence post. Fill any void between such fence posts and the metal sleeve using sulfur, a non-shrink grout, or PCC as directed by the Engineer. Wait seven (7) days after placing PCC to install materials on posts. Position fence to follow the ground contour with the bottom of the fence between one (1) inch and six (6) inches above the ground. Construction of PCC footings shall be considered subsidiary to the items for which the Contract provides direct payment.

Thoroughly clean welded connections on gate frames with burned smelter coating using a wire brush. Remove traces of the welding flux and any loose or cracked smelter. Paint the cleaned areas with two coats of zinc-oxide paint acceptable to the Engineer. Provide a PCC footing for drop-bar-locking devices on double gates. Make a hole using a metal sleeve to receive the locking bar to the depth specified by the manufacturer of the locking device. Hinge each single gate to prevent removal of the gate without tools. Set the gate in an approximately horizontal plane. Set the gate so it swings freely inward and outward and fastens securely in its latch holder or, in the case of double gates, in its latch holder and gate stops. Set double gates on their respective hinge pintles to provide a common horizontal plane in which each single gate swings. Set gates to swing open at least ninety (90) degrees in each direction.

(B) Grounding.

Supply and install a driven ground rod(s) at each crossing of an electric transmission, distribution, or secondary line with a metal fence, gate, or post. The ground rod shall extend a minimum of eight (8) inches above the finished ground elevation and a minimum of eight (8) vertical feet beneath the bottom of the fence. Install the ground rod in accordance with NEC Article 250. Connect the grounding rod to each fence element using a No. 6 AWG stranded copper wire connected by brazing or non-corrosive fastening clamps. Ground the fence at each end or gate post or at maximum intervals of one thousand six hundred (1,600) feet when an electric transmission, distribution, or secondary line runs parallel or nearly parallel to and above the fence. Use an equivalent horizontal grounding system acceptable to the Engineer if vertical installation of the grounding rod is impossible.

(C) Chain Link Fence Installation.

Install all chain-link fencing in accordance with ASTM F567, Standard Practice for Installation of Chain-Link Fence, or ASTM F969, Standard Practice for Construction of Chain-Link Tennis Court Fence, except as

modified herein. Measure the post-spacing interval horizontally. A corner is defined as any change in the fence alignment of twenty (20) degrees or more. Construct takedown panels and gates at the locations indicated in the Contract Documents or as directed by the Engineer. All material used for the takedown panels and gates shall be the same as those used for the remainder of the chain-link fence, including the tension bars and bands used for end, corner, and pull posts.

Install heavy malleable iron caps to hold the top rail and exclude moisture from inside the post on tubular line posts. Construct or equip "H" Section steel line posts with a device suitable for holding the top rail. Furnish all end, corner, gate, and pull posts with all necessary braces, truss rods, turnbuckles, tension bands, and fittings. Construct terminal installations when the chain-link fence intersects or joins an existing fence. Join rolls of fabric by weaving a single strand into the ends of the rolls to form a continuous mesh. Fasten fabric to the end bars of the gate frame by stretcher bars and fabric bands. Stretch the fence material using mechanical fence stretchers of sufficient capacity and design for such use. Firmly attach fencing to the posts and brace, tauten, and install to required elevations. Use a minimum of six (6) equally spaced fasteners to fasten the fabric to each ten (10) foot section rail. Use a minimum of one (1) fastener every twelve (12) inches to fasten the fabric to posts.

(D) Wood Fence Installation.
Install wood fence materials in accordance with ASTM F537, Standard Specification for Design, Fabrication, and Installation of Fences Constructed of Wood and Related Materials.

(E) PVC Fence Installation.
Install PVC fencing in accordance with ASTM F1999, Standard Practice for Installation of Rigid Poly(Vinyl Chloride) (PVC) Fence Systems.

(F) Bollards.
Drill holes for bollards at the locations indicated in the Contract Documents. The minimum diameter of the drilled hole shall be six (6) inches greater than the maximum cross-sectional diameter of the bollard. Set the bollards plumb and backfill using PCC to a minimum of two (2) inches above the surrounding ground. Dome the top of the PCC during finishing.

(G) Remove and Reset Fence.
Remove existing fence and reset to approximately the same condition as the original fence. Salvage material in the existing fence and incorporate the material into the reset fence. Remove, store, and reset existing fence when specified. Reset to meet provisions for setting new fence as applicable. When posts are set in concrete, remove concrete from old posts and reset in concrete. Replace fence material damaged

beyond re-use. Space the posts and attach fencing to the posts to match the original fence. Furnish and use new material to fasten members or wires to posts as necessary. New fastening materials are incidental to items for which the Contract provides direct payment.

813.04 Measurement and Payment.

The Engineer shall measure fence for payment as a single unit defined as the number of linear feet of each type and size of fence supplied, constructed, and accepted excluding any lengths for takedown panels and gates. The Engineer shall measure fence along the bottom of the fence from center of post to center of post.

The Engineer shall measure takedown panels for payment as a single unit defined as the number of each type and size of takedown panel supplied, constructed, and accepted.

The Engineer shall measure gates for payment as a single unit defined as the number of each type and size of gate supplied, constructed, and accepted.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This contract price shall be full compensation for site preparation, excavation, backfilling, furnishing and installing all footings, materials, fittings, fence fabric, and posts; and for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Construct ___ Fence	Linear Foot
Construct ___ Fence Gate	Each
Construct ___ Fence Takedown	Each
Provide Security Fencing	Lump Sum
Remove And Replace ___ Fence	Linear Foot
Relocate ___ Fence	Linear Foot

900 TRAFFIC

901 – POLES, MAST ARMS, AND CANTILEVER STRUCTURES

901.01 Description.

This work includes furnishing and installing of span wire poles, mast arm poles, combination mast arm and lighting poles, cantilever sign structures, street light poles, and pedestal poles including all materials, equipment, labor, tools, transportation, permits, licenses, and all other miscellaneous items as required by the Contract Documents.

901.02 Material Requirements.

(A) General.

Metal span wire poles, mast arm poles, combination mast arm and lighting poles, cantilever sign structures, street light poles, and pedestal poles shall be galvanized steel or aluminum structures designed in accordance with AASHTO Specifications for the Design and Construction of Structural Supports for Highway Signs. The maximum design wind velocity shall be one hundred (100) miles per hour with a one and three-tenths (1.3) gust factor after installation. A Structural Engineer currently licensed to practice in the State of Nebraska shall seal all designs.

Design structures to support the required signal heads, lighting systems, signal and lighting cables, signage, other required items, and ten (10) pounds of ice per linear foot per tube for the location and span indicated in the Contract Documents. Use the area of the signs shown plus thirty (30) percent or as noted on the Contract Documents for design calculations. Once selected, use the same design patterns, materials, and basic member shape throughout the project unless otherwise indicated in the Contract Documents.

When indicated in the Contract Documents, design cantilever sign structures to include lighting and a walkway. Design the walkway to be continuous over the roadway and shoulder on and in front of the lower chord. Design railing along the front side that folds down when not in use. No part of the walkway or railing in the folded position shall obstruct normal viewing of the sign(s).

Fabricate poles and arms in a plant owned and operated by a fabricator having sufficient experience to manufacture the structures in accordance with the Contract Documents. Provide the name and address of the fabricator and evidence of the fabricator's qualifications and experience upon request by the Engineer. Aluminum or steel galvanize structural components after fabrication unless otherwise indicated in the Contract Documents or directed by the Engineer.

(B) Metal Poles.

Metal poles shall consist of a round, tapered pole shaft of galvanized steel fabricated to the dimensions and details required in the Contract Documents. Metal poles shall have one (1) longitudinal automatic electric weld. After forming, flatten the weld. Steel shall meet the requirements of ASTM A595, Standard Specification for Steel Tubes, Low Carbon, Tapered for Structural Use. Incorporate a lifting U-hook at the top of the shaft. The U-hook shall be capable of supporting the weight of the entire pole.

For mast arm installations, design metal poles to support the required mast arms, signal heads, signal and lighting cables, signage and up to ten (10) pounds of ice per linear foot. For span wire installations, design metal poles to support the required signal heads, signal and lighting cables, and signage for the span length required with a worst angle of seventy (70) degrees. For all other installations, design metal poles to support the required signal heads, signal and lighting cables, signage and up to ten (10) pounds of ice per linear foot. The maximum design wind velocity for all installations shall be one hundred (100) miles per hour after installation. Design all metal poles to support a twenty (20) foot luminaire extension with a fifteen (15) foot luminaire arm and seventy-five (75) pound luminaire.

The pole manufacturer shall state the amount of pole rake necessary for the pole to set plumb under the required loading after installation. The pole manufacturer shall certify that the signal poles and related hardware will not fail under the loading requirements indicated in the Contract Documents.

Secure a one (1) piece galvanized steel anchor base of adequate strength, shape, and size to the lower end of the shaft using two (2) continuous electric arc welds. The base shall telescope the shaft of the pole. Locate one (1) weld inside the base at the end of the shaft. Locate one (1) weld outside the base at the joint between the base top and the pole shaft.

Furnish all hardware necessary to complete the metal pole assembly in accordance with the pole manufacturer's instructions. Hardware shall include but not be limited to bolts, nuts, washers, removable pole tops, anchor bolts, anchor bolt covers, and transformer bases. Galvanize all exposed metal hardware. Removable pole tops shall consist of a galvanized positioning cap screw and galvanized pole cap. Furnish one (1) rubber grommet of one (1) inch inside diameter for each signal arm mounting location. Furnish transformer bases for all installations at signalized intersections. Furnish transformer bases for all installations between signalized intersections as directed by the Contract Documents.

Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

(C) Wood Poles.

Wood poles shall be southern pine, douglas fir, western red cedar, or northern white cedar conforming to ASTM D25, Standard Specification for Round Timber Piles, and ANSI 05.1, Wood Poles, Specifications and Dimensions. Treat poles using the Rueping Process with a minimum of ten (10) pounds of five (5) percent pentachlorophenol solution per cubic foot of timber in accordance with AASHTO M133, Preservatives and Pressure Treatment Process for Timber. Roof, gain, and bore poles before full-length preservation treatment. Locate markings ten (10) feet above the butt of the pole. Cut gains on the concave side or side having the greatest curvature in poles having a reverse or double sweep. Gained surfaces shall be in parallel planes.

Poles in line shall not have sweeps or short crooks exceeding fifty (50) percent of the maximum allowed. Less than twenty (20) percent of the poles shall contain the maximum allowable sweeps and short crooks.

Store poles by stacking on creosote-treated or decay-resisting skids at least one (1) foot above the ground. Arrange skids to avoid distortion of the poles. Stack poles to permit free circulation of air. Remove any decaying wood from beneath stored poles immediately.

(D) Pedestal Traffic Signal Poles.

Pedestal traffic signal poles shall consist of a spun, seamless aluminum-alloy 6063-T6 shaft meeting the requirements of ASTM B429, Standard Specification for Aluminum-alloy Extruded Structural Pipe and Tube. The minimum wall thickness of the pole shall be one-fourth (¼) inch. The minimum inside diameter shall be four (4) inches. The minimum outside diameter shall be four and one-half (4½) inches.

Support the pole using a breakaway base comprised of cast aluminum meeting the requirements of ASTM B179, Standard Specification for Aluminum-alloys in Ingot and Molten Forms for Castings. The breakaway base shall have an approximate height of fifteen (15) inches with a diameter of seventeen (17) inches or less.

Design the pedestal traffic signal pole and breakaway base to support the pole, signal load, signal and lighting cables, and ice loading of ten (10) pounds per linear foot. The maximum design wind velocity shall be one hundred (100) miles per hour after installation. The manufacturer shall design and test the breakaway base in accordance with all applicable AASHTO requirements.

Furnish all hardware necessary to complete the pedestal traffic signal pole assembly in accordance with the pole manufacturer's instructions. Hardware shall include but not be limited to bolts, nuts, washers,

anchor bolts, anchor bolt covers, and pole bases. Galvanize all exposed metal hardware. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. Furnish one (1) rubber grommet of one (1) inch inside diameter for each signal or luminaire mounting location.

(E) Anchor Bolts.

Anchor bolts shall conform to the requirements of ASTM A307, Standard Specification for Carbon Steel Externally and Internally Threaded Standard Fasteners, and the Contract Documents. The pole manufacturer shall certify that the strength of the anchor bolts is sufficient for the loading requirements of the pole. The minimum yield strength shall be sixty thousand (60,000) psi. Thread the bolts a sufficient length to allow for proper installation. Threads shall be full and sound. Galvanize all exposed portions of the anchor bolt. Supply two (2) galvanized hexagon nuts and two (2) galvanized flat washers with each anchor bolt. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

(F) Transformer Bases.

Transformer bases shall be galvanized steel meeting the requirements of ASTM A27, Standard Specification for Steel Castings, Carbon, for General Application. The transformer base shall be of adequate size and shape for the pole anchor base and pole foundation. The manufacturer shall certify that the transformer base meets the strength requirements for the anticipated loading. The transformer base shall have a weather-tight hand hole reinforced to maintain the full strength of the transformer base. The minimum opening size shall be eight (8) inches by thirteen (13) inches. Furnish a grounding nut that accommodates a No. 6 AWG copper grounding wire on the inside of the transformer base.

(G) Signal Mast Arms.

Signal mast arms shall consist of a galvanized steel shaft with a clamp-on mounting device suitable for attaching the arm at the height specified in the Contract Documents. Signal mast arms less than fifty-five (55) feet shall be one (1) piece arms. Signal mast arms fifty-five (55) feet or longer may be one (1) or two (2) piece arms. Steel shall meet the requirements of ASTM A595, Standard Specification for Steel Tubes, Low Carbon, Tapered for Structural Use. The clamp-on mounting shall be structurally sound and neat in appearance. The signal mast arm shall be field adjustable or provide a minimum of two (2) and a maximum of four (4) degree rise. Supply a mast arm cap for the free end of the mast arm. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. Furnish one (1) rubber grommet of one (1) inch inside diameter for each signal mounting location. Design signal mast arms to support the required signal or luminaire load and the

required signal and lighting cables. The maximum design wind velocity shall be one hundred (100) miles per hour after installation.

(H) Luminaire Arms and Extensions.

Luminaire arms and extensions shall consist of a galvanized steel shaft with a mounting device suitable for attaching the arm and/or extension at the height specified in the Contract Documents. Steel shall meet the requirements for two (2) inch Grade A or Schedule 40 pipe as defined by ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless. The mounting shall be structurally sound and neat in appearance. The mating arm and pole steel simplex attachments shall meet the requirements for Grade 65-35 steel castings as defined by ASTM A27, Standard Specification for Steel Castings, Carbon, for General Applications. Channel scrolls shall be one and one-half (1½) inch by one and one-half (1½) inch by one-eighth ($^1/_8$) inch commercial grade steel.

(I) Sealing Compound.

Aluminum-filled, resilient sealing compound shall be Minnesota Mining and Manufacturing Company (3M) Sealant Number 1168 or approved equal.

(J) Pipe Handrails.

Pipe handrails shall be of Aluminum-alloy 6061-T6 or Alloy 6063-T6 and shall conform to the requirements of ASTM B221, Standard 'Specification for Aluminum-alloy Extruded Bars, Rods, Shapes and Tubes; or ASTM B241 Standard Specification for Aluminum and Aluminum-alloy Seamless Pipe and Seamless Extruded Tube.

(K) Copper Grounding Wire, Grounding Rods, and Test Stakes.

Copper grounding wire shall be No. 6 AWG stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire. Copper grounding wire installed in conduit shall be No. 6 AWG green insulated stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire. Grounding rods and test stakes shall comply with IMSA Specification Number 62-1956 excluding length and diameter requirements. Ground rods and test stakes shall have a minimum diameter of five-eighths ($^5/_8$) inch. Supply ground rods and test stakes with a ground rod clamp.

(L) Grout.

Grout shall be non-shrinking and non-rusting and comply with the requirements for Grade A Pre-Hardening Volume-Adjusting Grout as defined by ASTM C1107, Standard Specification for Packaged Dry, Hydraulic-Cement Grout.

(M) Anchors and Anchor Rods.

Anchors shall be three-way (3-way) expanding malleable iron anchors having a minimum diameter of eight (8) inches. Malleable iron shall

conform to the requirements of ASTM A47, Standard Specification for Ferritic Malleable Iron Castings. Anchor rods shall be eight (8) foot long, five-eighths (5⁄8) inch diameter galvanized steel rods with a thimbleye end. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

(N) Guy Wire and Guy Guards.
Guy wire shall be three-eighths (3⁄8) inch diameter, seven (7) wire, high-strength grade cable with Class A zinc coating meeting the requirements of ASTM A475, Standard Specification for Zinc-Coated Steel Wire Strand. Guy guards shall be eight (8) foot long, half-round, galvanized metal guards. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

(O) Bonding Clamps.
Bonding clamps shall be galvanized metal clamps that expand by tightening a set screw. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

(P) Span Wire Cable.
Span wire cable shall be three-eighths (3⁄8) inch diameter, seven (7) wire, high-strength grade cable with Class A zinc coating meeting the requirements of ASTM A475, Standard Specification for Zinc-Coated Steel Wire Strand.

(Q) Traffic Signal Tie Wire.
Traffic signal tie wire shall be one-fourth (¼) inch diameter, seven (7) wire, Siemens-Martin or equal grade cable with Class A zinc coating meeting the requirements of ASTM A475, Standard Specification for Zinc-Coated Steel Wire Strand.

(R) Conduit and Conduit Fittings.
Conduit and conduit fittings for direct bury applications shall be galvanized rigid steel conforming to UL-6, UL Standard for Safety for Electrical Rigid Metal Conduit – Steel; high-density polyethylene conforming to ASTM F2160, Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD); or rigid polyvinyl chloride conforming to UL-651, UL Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit. Conduit and conduit fittings for boring applications shall be high density polyethylene conforming to ASTM D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter. Furnish in standard lengths with UL label. Rigid steel conduit fittings shall be galvanized steel or galvanized malleable iron. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings

on Iron and Steel Products. PVC conduit fittings and cement shall be compatible with the PVC conduit. Transitions between HDPE and PVC conduits shall conform to the manufacturer's recommendations. Conduit size shall be the minimum trade size permitted for the application. Conduit installed for above ground risers shall be galvanized rigid steel conduit.

(S) Portland Cement.

Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3.

(T) Water.

All water used in PCC shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(U) Aggregate.

Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(V) Admixtures.

Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride flake in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC.

Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the

manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(W) PCC Mix Proportioning.

Proportion PCC mixtures to meet the requirements of Table 901.01.

Table 901.01
PCC Properties

Mix Type	L6
Portland Cement Content, lbs. per cubic yard	564
Coarse Aggregate, % of Total Aggregate	30±3
Fine Aggregate, % of Total Aggregate	70±3
Maximum Water Cement Ratio	0.45
Minimum 28-Day Compressive Strength, psi	3500
Air Content, %	6.5±1.0
Slump, inches	4-inch Max.
Concrete Temperature during placement, °F	70±25

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(X) Reinforcing Steel.

Reinforcing steel shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

(Y) Pre-molded Joint Filler.

Pre-molded joint filler for expansion joints shall conform to the requirements of ASTM D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). Neatly punch holes to admit the dowels where indicated in the Contract Documents. The diameter of the holes shall not exceed one-half (½) inch greater than the bar diameter. When more than one piece is required for a joint, securely fasten the abutting ends by stapling or other positive fastening means satisfactory to the Engineer.

(Z) Curing Materials.

Curing materials shall be membrane-forming compounds or polyethylene film. Liquid, membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete

901.03 Construction Requirements.

(A) General.

Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 901.02 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents. At the time of each submittal, identify in writing any deviations that the shop drawings or samples may have from the requirements of the Contract Documents.

Table 901.02
Materials Information Requirements

Item	Required Information
Metal Poles	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance, Mill Test**, Design Calculation**
Mast Arms	Manufacturer's Model or Catalog Number, Certificate of Compliance, Mill Test**, Design Calculation**
Pedestal Poles	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance, Mill Test**, Design Calculation**
Anchor Bolts	Manufacturer's Model or Catalog Number, Certificate of Compliance
Breakaway Devices	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance, Mill Test**, Design Calculation**
Wire and Cable	Manufacturer's Model or Catalog Number, Certificate of Compliance
Conduit	Manufacturer's Model or Catalog Number
Wood Poles	Manufacturer's Model or Catalog Number, Manufacturer's Data identifying Species, Size, Class, and Treatment
Wood Pole Fittings	Manufacturer's Model or Catalog Number
Pole Guys and Hardware	Manufacturer's Model or Catalog Number, Certificate of Compliance
Guy Anchors	Manufacturer's Model or Catalog Number, Certificate of Compliance

* As required by the Engineer

** May substitute catalog number or model number for shop drawing as permitted by the Engineer

Before ordering structural steel, locate overhead or underground utilities to verify that they do not interfere with the work outlined in the Contract Documents. Order all poles, mast arms, span wires, anchors,

and related materials necessary to complete the work no later than ten (10) calendar days after receiving approval of the submitted materials information. Submit proof of the orders and estimated delivery time to the Engineer within fifteen (15) calendar days after receiving approval of the submitted materials information. Identify any materials already in possession. Do not substitute items without written permission from the Engineer. Do not construe Engineer's acceptance of a submittal as relieving the Contractor of the responsibility to comply with the Contract Documents.

Obtain all licenses and permits before commencing the work.

A competent worker experienced in the required work shall perform all work under the supervision of a licensed journeyman electrician or lineman. A qualified journeyman electrician or lineman shall directly supervise any work involving the installation of cable, foundations, structural steel, and traffic control equipment. Installations shall comply with all applicable sections of the National Electrical Code, National Electrical Safety Code, Manual on Uniform Traffic Control Devices, all governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Inform the Engineer of the work scheduled each day. Schedule work to minimize the time any signal is inoperable. During this time, provide, place, and maintain temporary traffic control devices in accordance with the City of Omaha's "Manual of Barricading Standards, Specifications, Methods, and Materials". Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Provide the utility company supplying the electrical service adequate notice regarding the scope and nature of the power requirement. Arrange for all necessary electrical services at locations indicated in the Contract Documents. The utility company or Engineer may alter the service location in the field to adapt to certain field requirements. Cooperate with the utility company providing electrical service in locating the service lines and conduit bends.

Trim trees or shrubs using proper tree surgery practices to trim tree branches as necessary to install the poles, mast arms, span wires, or pole. Use an asphaltum-based paint manufactured for tree surgery to treat the cut or scarred branches.

Do not disconnect or damage an operational communication cable while performing work around traffic signal systems without written permission from the Engineer. Reconnect, repair, or establish a temporary connection within eight (8) hours of disconnecting or damaging a communication cable.

Size conduit bends installed in existing foundations to be equivalent to the connecting conduit in the ground. Do not cut or damage the reinforcing steel or anchor bolts in the foundation. Install the conduit a minimum depth of twelve (12) inches below the top of the foundation or thirty (30) inches below the depth of the surrounding ground surface, whichever is greater. Remove a sufficient amount of concrete to place the conduit inside the anchor bolts of the foundation. Position the conduit and place concrete or grout. Finish to match the existing foundation.

Replace or restore in kind equal to or exceeding any surface materials disturbed by trenching, excavating, or backfilling operations. Accomplish restoration in accordance with the Contract Documents. Dispose of all excess materials as directed by the Engineer.

Transfer any guarantees or warranties on materials purchased to the City upon acceptance of the work. Purchase materials with transferable guarantees or warranties.

(B) Metal Pole and Pedestal pole Installation.

Metal pole foundations for use with mast arm lengths less than or equal to sixty-one (61) feet shall comply with the Contract Documents. Provide a structural engineering design on all metal pole foundations where the mast arm length exceeds sixty-one (61) feet. A Structural Engineer currently licensed to practice in the State of Nebraska shall seal the design.

Dig or bore holes to the lines and depth specified in the Contract Documents for the construction of the metal pole foundation. Metal pole foundations shall be round. Pedestal pole foundations shall be round or square. Construct forms for the upper two (2) feet of the metal pole foundation. The minimum dimension for the mounting surface shall be two and one-half (2½) inches greater than the pole base or transformer base on all sides. The excavation shall be dry and free of any loose materials before placing PCC. Level and secure all forms to the satisfaction of the Engineer before commencing PCC placement.

Forms shall be wood, metal, or seamless laminated fiber tubes acceptable to the Engineer. Construct forms to be mortar-tight and rigid to prevent distortion due to pressure created by the PCC construction. Do not use aluminum forms.

Supply and install a driven ground rod(s) at the base of each pole as indicated in the Contract Documents before commencing PCC placement. The ground rod shall extend a minimum of eight (8) inches above the finished foundation and a minimum of eight (8) feet beneath the bottom of the foundation. Install the ground rod in accordance with NEC Article 250.

Install and secure all reinforcing steel and conduit in a manner acceptable to the Engineer. Center the bolt circle in the middle of the foundation and set the anchor bolts plumb in the foundation at a projection distance in accordance with the pole manufacturer's instructions. Conduit bends shall be ninety (90) degrees and shall exit the foundation a minimum of thirty (30) inches below the level of the surrounding ground. Plug the ends of the conduit before commencing PCC placement. Install pre-formed expansion joint material between the pole foundation and any abutting PCC structure.

Provide all equipment, labor, and tools necessary to perform the work to the satisfaction of the Engineer. The National Ready Mixed Concrete Association shall certify that the production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement and embedded items are properly prepared and free of mud, oils, or other

coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

Place the PCC continuously in horizontal layers not exceeding eighteen (18) inches. Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows placement operations to continue as uninterrupted as possible. Place PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Do not allow the PCC to drop more than five (5) feet from the end of the discharge chute. Use a metal pipe or channel to deliver PCC at depths greater than five (5) feet. Handle the PCC in a manner that minimizes segregation.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

During cold weather periods, place PCC only when the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature falls below forty (40) degrees Fahrenheit. Do not place PCC on frozen materials.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements. Do not place PCC at night without the Engineer's permission. The Contractor

is responsible for any damage to the PCC due to weather conditions or other factors.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

Consolidate the PCC throughout the length of the foundation by inserting and withdrawing a vibrator(s) at a minimum of four (4) locations within the foundation. Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC. Do not drag the vibrator through the PCC. Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

Finish the top of the foundation to be approximately one (1) inch above the adjacent ground or structure unless otherwise indicated in the Contract Documents. Finish the top of the foundation to be equal with the surrounding sidewalk elevation when constructing a foundation within the limits of a sidewalk.

Protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds for a minimum of three (3) days. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer.

Remove forms as soon as practicable after the PCC has hardened without damaging the PCC. Remove any PCC surface irregularities exposed by the removal of the forms by sanding or filling with mortar in a manner acceptable to the Engineer.

Backfill the excavation and restore any areas disturbed by the foundation construction. Backfill the foundation with lean clay or silty

clay materials compacted to ninety-five (95) percent of the maximum density determined in accordance with ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

Dress the top of the PCC foundation to provide for proper seating of the pole base. Heavily coat all areas that contact the PCC foundation on all aluminum bases with an aluminum-filled, resilient sealing compound. Install the poles in accordance with the manufacturer's recommendations and the Contract Documents. Position the pole with the hand hole facing away from vehicular traffic wherever possible. Install leveling nuts as directed by the pole manufacturer regardless of the need for adjustment. Install a one (1) inch inside diameter rubber grommet below the mast arm installation location. Plumb pedestal poles using shims supplied by the pole base manufacturer. After plumbing the metal pole, fill any void between the pole base and the pole foundation with grout. Install a one-half (½) inch conduit in the grout for drainage as directed by the Engineer.

Install a No. 6 AWG stranded green insulated copper conductor attached to the ground rod using an approved clamp and connected to the grounding lug on the pole shaft. Grounding shall be in accordance with the NEC, local ordinances, all applicable codes, and the requirements of the local utility company supplying electrical power. The Engineer shall resolve any discrepancies. Do not connect any grounding connections to a breakaway device. The maximum measurable resistance between the ground rod and a test stake driven two (2) feet into the ground adjacent to the PCC pole foundation shall not exceed twenty-five (25) ohms. If the resistance exceeds twenty-five (25) ohms, install additional ground rods, greater than six (6) feet apart and connected using a No. 4 AWG bare copper wire. The number of additional ground rods shall be as needed to produce a measurable resistance of less than twenty-five (25) ohms.

(C) Wood Pole Installation.

Install wood poles at locations that do not detract from the general appearance of a line of poles and are acceptable to the Engineer. Dig or bore holes to the lines and depth specified in the Contract Documents for the construction of the wood pole foundation and anchors. Holes shall be round. Minimize the diameter of all holes.

Do not drag treated poles along the ground. Do not handle poles using pole tongs, cant hooks, or other tools that produce indentations greater than one (1) inch. Do not apply tools to the section of the pole located one (1) foot above and two (2) feet below the foundation surface. Install the wood pole such that the pole is plumb after installation. Install an eight (8) inch, three-way (3-way) anchor a minimum of seven and one-half (7½) feet into the ground. Attach a seven (7) foot anchor rod to the anchor in accordance with the manufacturer's instructions.

Verify that the wood pole is plumb before backfilling commences. Backfill the excavation and restore any areas disturbed by the wood pole installation. Backfill the foundation with lean clay or silty clay materials compacted to ninety-five (95) percent of the maximum density determined in accordance with ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort. Place backfill materials in uniform horizontal layers not exceeding eight (8) inches loose lift thickness.

Attach the guy wire(s) to pole using a three-fourths (¾) inch thimbleye bolt mounted at an angle approximately equal to the angle of the guy wire(s) to the pole. Attach an insulator approximately eighteen (18) feet above the pole foundation to the guy wire(s) using preformed wire deadends or strandvises. Install a half-round guy guard on the lower seven (7) feet of the guy wire(s). Attach the guy wire(s) to an anchor rod using a preformed wire deadend or strandvise.

Supply and install a driven ground rod(s) at the base of each pole as indicated in the Contract Documents. The ground rod shall extend a minimum of eight (8) inches above and a minimum of eight (8) feet beneath the surface of the adjacent ground. Install the ground rod in accordance with NEC Article 250. Install a No. 6 AWG stranded copper wire attached to the ground rod using an approved clamp and connected to the splice box on the pole shaft. Use No. 6 AWG green insulated stranded copper wire for conduit installations. Grounding shall be in accordance with the NEC, local ordinances, all applicable codes, and the requirements of the local utility company supplying electrical power. The Engineer shall resolve any discrepancies. Do not connect any grounding connections to a breakaway device. The maximum measurable resistance between the ground rod and a test stake driven two (2) feet into the ground adjacent to the pole foundation shall not exceed twenty-five (25) ohms. If the resistance exceeds twenty-five (25) ohms, install additional ground rods greater than six (6) feet apart and connected using a No. 4 AWG bare copper wire. The number of additional ground rods shall be as needed to produce a measurable resistance of less than twenty-five (25) ohms.

(D) Mast Arm Installation.

Install mast arms in accordance with the manufacturer's instructions such that the loaded arm has a minimum clearance of seventeen (17) feet from bottom of all signals to the crown of the roadway. The minimum rise of the end of the loaded arm shall be zero (0) degrees. Install a one (1) inch or greater inside diameter rubber grommet on the bottom of the mast arm near the connection to the pole as indicated in the Contract Documents or as directed by the Engineer. Rake the pole back more than the calculated deflection, load the pole, and plumb the pole by adjusting the leveling nuts.

(E) Span Wire and Tie Wire Installation.

Install span wires such that the loaded span wires have a minimum clearance of twenty-one (21) feet above the crown of the roadway and sag of three (3) to five (5) percent of the span length. Bond the span wire to the grounding system. Install tie wire(s) when required by the Contract Documents. Attach tie wire(s) to the pole approximately eight (8) inches below the base of the signal head. Attach the span wire(s) and tie wire(s) to the wood pole using a three-fourths (¾) inch thimbleye bolt mounted perpendicular to the centerline of the pole. Install a 2 and one-half (2½) inch by seven and one-fourth (7¼) inch lift plate directly across from the thimbleye bolt in accordance with the manufacturer's instructions using one-half (½) inch by four (4) inch lag screws. Attach the thimbleye bolt to the lift plate.

(F) Luminaire Installation.

If required, remove the pole cap and bolt the luminaire extension to the pole. Attach the luminaire arm in accordance with the Contract Documents and the manufacturer's instructions. Provide and install conductors in the pole shaft and luminaire arm. Hook up the luminaire head. Connect the conductors in the pole shaft to the 3/C street lighting cable as shown on the plans. Connect the 3/C street lighting cable to the proper circuit breaker at the service disconnect pedestal unless otherwise indicated in the Contract Documents or directed by the Engineer.

901.04 Measurement and Payment.

The Engineer shall measure installation of furnished materials for payment as single units for each item. When materials are furnished, accept delivery of the specific items furnished at the location outlined in the Contract Documents.

The Engineer shall measure mast arm signal poles for payment by the number of mast arm signal poles supplied and accepted.

The Engineer shall measure combination mast arm signal and lighting poles for payment by the number of combination mast arm signal and lighting poles supplied and accepted.

The Engineer shall measure pedestal pole installation for payment by the number of pedestal poles installed and accepted.

The Engineer shall measure metal poles for payment by the number of metal poles supplied and accepted.

The Engineer shall measure wood poles for payment by the number of wood poles supplied and accepted.

The Engineer shall measure span wire installation for payment by the linear feet of span wire installed between poles and accepted. Do not include sag in the measurement of the span wire.

The Engineer shall measure tie cable installation for payment by the linear feet of tie cable installed between poles and accepted. Do not include sag in the measurement of the tie cable.

The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of any foundation design associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of the tree or shrub trimming is subsidiary to items for which the Contract provides direct payment. Loading, hauling, construction of all materials, mounting hardware, additional grounding rods, and all miscellaneous hardware is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents. Any costs associated with installing wire/conduit into an existing base/foundation/pad are subsidiary to items for which the Contract provides direct payment. Mast arms and luminaire arms are subsidiary to mast arm signal poles and combination mast arm signal and lighting poles. Costs associated with restoration of the surface are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. The contract price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Mast Arm Signal Pole, Type MP-___	Each
Combination Mast Arm Signal & Lighting Pole, Type CMP-___-___	Each
Install Mast Arm Pole	Each
Pedestal Pole, Type PP-__	Each
Install Pedestal Pole, Type PP-__	Each
___ - foot Wood Pole	Each
Install Wood Pole	Each
Street Light Pole - 6' Luminaire Arm	Each
Street Light Pole - 12' Luminaire Arm	Each
Install ___W Street Light Luminaire	Each
Span Wire	Linear Feet
Tie Cable	Linear Feet

902 – TRUSS STRUCTURES

902.01 Description

This work includes supplying and construction of steel or aluminum single panel or box truss structures for erecting traffic signals or signs as indicated in the Contract Documents. Steel or aluminum box trusses with single pole or vertical end frames shall span multi-lane roadways and shall include a sign lighting system as required by the Contract Documents.

902.02 Material Requirements

(A) General.

Truss structures shall be box or single panel trusses designed in accordance with AASHTO Specifications for the Design and Construction of Structural Supports for Highway Signs. The maximum design wind velocity shall be one hundred (100) miles per hour with a one and three-tenths (1.3) gust factor after installation. A Structural Engineer currently licensed to practice in the State of Nebraska shall seal all designs.

Design structures to support the required signal heads, lighting systems, signal and lighting cables, signage, other required items, and ten (10) pounds of ice per linear foot per tube for the location and span indicated in the Contract Documents. Use the area of the signs shown plus thirty (30) percent or as noted on the Contract Documents for design calculations. Once selected, use the same design patterns, materials, and basic member shape throughout the project unless otherwise indicated in the Contract Documents. Design truss structures to be supported by single poles or end frames having no more than two (2) vertical main members of a closed cross section.

When indicated in the Contract Documents, truss structures intended to support signs only shall include lighting and a walkway. Design the walkway to be continuous over the roadway and shoulder on and in front of the lower chord. Design railing along the front side that folds down when not in use. No part of the walkway or railing in the folded position shall obstruct normal viewing of the sign(s).

Fabricate truss structures in a plant owned and operated by a fabricator having sufficient experience to manufacture the structures in accordance with the Contract Documents. Provide the name and address of the fabricator and evidence of the fabricator's qualifications and experience upon request by the Engineer. Aluminum or steel galvanize truss structure after fabrication unless otherwise indicated in the Contract Documents or directed by the Engineer.

(B) Extruded Tubes.
Extruded tubes for chord and column members shall be of Aluminum-alloy 60610-T6 and shall conform to the requirements of ASTM B221, Standard Specification for Aluminum-alloy Extruded Bars, Rods, Shapes, and Tubes. Extruded tubes for bracing members shall conform to the requirements of Aluminum-alloy 6063-T6, or ASTM B429 Standard Specification for Aluminum-alloy Extruded Structural Pipe and Tube.

(C) Extruded Shapes.
Extruded shapes shall be of Aluminum-alloy 6061-T6 and shall conform to the requirements of ASTM B221, Standard Specification for Aluminum-alloy Extruded Bars, Rods, Shapes, and Tubes; or ASTM B308, Standard Specification for Aluminum-alloy Standard Structural Shapes Rolled or Extruded.

(D) Aluminum Plates.
Plates shall be of Aluminum-alloy 6061-T6 and shall conform to the requirements of ASTM B209, Standard Specification for Aluminum and Aluminum-alloy Sheet and Plate.

(E) Aluminum Castings.
Castings for post bases and chord flanges shall be Alloy SG70A-T6 or Alloy SG70B-T61 and shall conform to the requirements of ASTM B26, Standard Specification for Aluminum-alloy Sand Castings; or ASTM B108, Standard Specification for Aluminum-alloy Permanent Mold Castings.

(F) Aluminum Gratings.
Material for grating shall be Aluminum-alloy 6061-T6 for bearing bars and Alloy 6063-T5 for cross or crimp bars and shall conform to the requirements of ASTM B211, Standard Specification for Aluminum and Aluminum-alloy Bars, Rods and Wire; or ASTM B221, Standard Specification for Aluminum-alloy Extruded Bars, Rods Shapes and Tubes.

(G) Pipe Handrails.
Pipe handrails shall be of Aluminum-alloy 6061-T6 or Alloy 6063-T6 and shall conform to the requirements of ASTM B221, Standard 'Specification for Aluminum-alloy Extruded Bars, Rods, Shapes and Tubes; or ASTM B241 Standard Specification for Aluminum and Aluminum-alloy Seamless Pipe and Seamless Extruded Tube.

(H) Post and Chord Caps.
Post and chord caps shall be Alloy SG70A-F as defined by ASTM B26, Standard Specification for Aluminum-alloy Sand Castings.

(I) Hardware.

Anchor bolts, flange bolts, and nuts shall conform to the requirements of ASTM A307, Standard Specification for Carbon Steel Externally and Internally Threaded Standard Fasteners. All other hardware shall be of good commercial quality. Galvanizing as required on plans shall be in accordance with ASTM A153, Standard Specification for Zinc Coating on Iron and Steel Hardware.

(J) Welding Materials and Welded Materials.

Welding materials and Welded materials shall conform to the requirements of AWS D2.0, Specifications for Welded Highway and Railway Bridges

(K) Structural Steel.

Structural steel shall be Grade D or E as defined by ASTM A588, Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi Minimum Yield Point to 4 in. Thick. Perform weldability tests on plates as defined by AWS D2.0, Specifications for Welded Highway and Railway Bridges. Submit proof of weldability to the Engineer before obtaining the structural steel. Use electrodes E 7016, E 7018, or E 7028. Do not stress-relieve test specimens.

(L) Sealing Compound.

Aluminum-filled, resilient sealing compound shall be Minnesota Mining and Manufacturing Company (3M) Sealant Number 1168 or approved equal.

(M) Copper Grounding Wire, Grounding Rods, and Test Stakes.

Copper grounding wire shall be No. 6 AWG stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire. Copper grounding wire installed in conduit shall be No. 6 AWG green insulated stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire. Grounding rods and test stakes shall comply with IMSA Specification Number 62-1956 excluding length and diameter requirements. Ground rods and test stakes shall have a minimum diameter of five-eighths ($^5/_8$) inch. Supply ground rods and test stakes with a ground rod clamp.

(N) Conduit and Conduit Fittings.

Conduit and conduit fittings for direct bury applications shall be galvanized rigid steel conforming to UL-6, UL Standard for Safety for Electrical Rigid Metal Conduit – Steel; high-density polyethylene conforming to ASTM F2160, Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD); or rigid polyvinyl chloride conforming to UL-651, UL Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit. Conduit and conduit fittings for boring applications shall be high density polyethylene conforming to ASTM D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on

Controlled Outside Diameter. Furnish in standard lengths with UL label. Rigid steel conduit fittings shall be galvanized steel or galvanized malleable iron. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. PVC conduit fittings and cement shall be compatible with the PVC conduit. Transitions between HDPE and PVC conduits shall conform to the manufacturer's recommendations. Conduit size shall be the minimum trade size permitted for the application. Conduit installed for above ground risers shall be galvanized rigid steel conduit.

(O) Portland Cement.

Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3.

(P) Water.

All water used in PCC shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(Q) Aggregate.

Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(R) Admixtures.

Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC.

Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(S) PCC Mix Proportioning.

Proportion PCC mixtures to meet the requirements of Table 902.02.

Table 902.02
PCC Properties

Mix Type	L6
Portland Cement Content, lbs. per cubic yard	564
Coarse Aggregate, % of Total Aggregate	30±3
Fine Aggregate, % of Total Aggregate	70±3
Maximum Water Cement Ratio	0.45
Minimum 28-Day Compressive Strength, psi	3500
Air Content, %	6.5±1.0
Slump, inches	4-inch Max.
Concrete Temperature during placement, °F	70±25

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(T) Reinforcing Steel.

Reinforcing steel shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement; or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

(U) Pre-molded Joint Filler.

Pre-molded joint filler for expansion joints shall conform to the requirements of ASTM D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). Neatly punch holes to admit the dowels where indicated in the Contract Documents. The diameter of the holes shall not exceed one-half (½) inch greater than the

bar diameter. When more than one piece is required for a joint, securely fasten the abutting ends by stapling or other positive fastening means satisfactory to the Engineer.

(V) Curing Materials.
Curing materials shall be membrane-forming compounds or polyethylene film. Liquid, membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete

902.03 Construction Requirements.

(A) General.
Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 902.03 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents. At the time of each submittal, identify in writing any deviations that the shop drawings or samples may have from the requirements of the Contract Documents.

Table 902.03
Materials Information Requirements

Item	Required Information
Truss Structure	Stamped Working Drawing, Certificate of Compliance, Mill Test**, Design Calculations**
Extruded Tubes and Shapes	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance, Mill Test**, Design Calculation**
Aluminum Plates	Manufacturer's Model or Catalog Number, Certificate of Compliance, Mill Test**, Design Calculation**
Aluminum Castings	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance, Mill Test**, Design Calculation**
Aluminum Grating	Manufacturer's Model or Catalog Number, Certificate of Compliance
Pipe Handrails	Manufacturer's Model or Catalog Number
Hardware	Manufacturer's Model or Catalog Number
Cantilever Sign Supports	Manufacturer's Model or Catalog Number
Steel Sign Brackets	Manufacturer's Model or Catalog Number
Welding Electrodes	Manufacturer's Model or Catalog Number
Conduit	Manufacturer's Model or Catalog Number

* As required by the Engineer
** May substitute catalog number or model number for shop drawing as permitted by the Engineer

Before ordering structural components, locate overhead or underground utilities to verify that they do not interfere with the work outlined in the Contract Documents. Order all structural components and related

materials necessary to complete the work no later than ten (10) calendar days after receiving approval of the submitted materials information. Submit proof of the orders and estimated delivery time to the Engineer within fifteen (15) calendar days after receiving approval of the submitted materials information. Identify any materials already in possession. Do not substitute items without written permission from the Engineer. Do not construe Engineer's acceptance of a submittal as relieving the Contractor of the responsibility to comply with the Contract Documents.

Obtain all licenses and permits before commencing the work.

A competent worker experienced in the required work shall perform all work under the supervision of a licensed journeyman electrician or lineman. A qualified journeyman electrician or lineman shall directly supervise any work involving the installation of cable, foundations, structural steel, and traffic control equipment. Installations shall comply with all applicable sections of the National Electrical Code, National Electrical Safety Code, Manual on Uniform Traffic Control Devices, AWS specifications, all governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Inform the Engineer of the work scheduled each day. Schedule work to minimize the time any signal is inoperable. During this time, provide, place, and maintain temporary traffic control devices in accordance with the City of Omaha's "Manual of Barricading Standards, Specifications, Methods, and Materials". Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Provide the utility company supplying the electrical service adequate notice regarding the scope and nature of the power requirement. Arrange for all necessary electrical services at locations indicated in the Contract Documents. The utility company or Engineer may alter the service location in the field to adapt to certain field requirements. Cooperate with the utility company providing electrical service in locating the service lines and conduit bends.

Trim trees or shrubs using proper tree surgery practices to trim tree branches as necessary to install the poles, mast arms, span wires, or pole. Use an asphaltum-based paint manufactured for tree surgery to treat the cut or scarred branches.

Do not disconnect or damage an operational communication cable while performing work around traffic signal systems without written permission from the Engineer. Reconnect, repair, or establish a temporary connection within eight (8) hours of disconnecting or damaging a communication cable.

Size conduit bends installed in existing foundations to be equivalent to the connecting conduit in the ground. Do not cut or damage the reinforcing steel or anchor bolts in the foundation. Install the conduit a minimum depth of twelve (12) inches below the top of the foundation or thirty (30) inches below the depth of the surrounding ground surface, whichever is greater. Remove a sufficient amount of concrete to place the conduit inside the anchor bolts of the foundation. Position the conduit and place concrete or grout. Finish to match the existing foundation.

Replace or restore in kind equal to or exceeding any surface materials disturbed by trenching, excavating, or backfilling operations. Accomplish restoration in accordance with the Contract Documents. Dispose of all excess materials as directed by the Engineer.

Transfer any guarantees or warranties on materials purchased to the City upon acceptance of the work. Purchase materials with transferable guarantees or warranties.

(B) Material Handling.

Use handling techniques that avoid scarring or marring the galvanized surface. The Engineer reserves the right to reject any such damage that, in the judgment of the Engineer, results in an objectionable appearance or a weakened structure. Remove all irregularities from cast parts. Tubing shall be seamless and exterior and interior surfaces shall be clean, smooth, and free from slivers, lamination, grooves, cracks, or other defects. The Engineer reserve the to reject any work containing poor welding workmanship, as noted by visual or other inspection.

(C) Fabrication of Structures.

Fabrication of structures shall conform to AWS recommendations and the following specific requirements. The Engineer shall resolve any conflicts.

- Do not flame cut aluminum-alloy materials.
- Shear, saw, or mill material having a thickness less than or equal to one-half (½) inch.
- Saw or mill material having a thickness greater than one half (½) inch. Sawed or milled edges shall be true and free of burrs or ragged breaks.
- Heating materials to a temperature exceeding four hundred (400) degrees Fahrenheit is acceptable for a period not exceeding fifteen (15) minutes to facilitate bending.

- Bolt holes shall be drilled full size, or sub-punched one-eighth ($^1/_8$) inch smaller than the nominal diameter of the fastener and reamed to size. Unless otherwise indicated on the plans, the finished diameter of the holes shall be not more than seven (7) percent greater than the nominal diameter of the fastener.
- The length of the vertical end frames for structures shall be field checked before fabrication.

(D) Aluminum Welding.

Pre-qualify all proposed joint welding procedures using tests prescribed in Part B, Section IV, of the ASME Boiler and Pressure Vessel Code. The Engineer reserves the right to accept evidence of previous qualifications of the proposed joint welding procedures.

Pre-qualify all welders or welding operators engaged in the work using tests prescribed in Part V, Section IX, of the ASME Boiler and Pressure Vessel Code. The Engineer reserves the right to accept evidence of previous qualification of the welders or welding operators. Use the same processes and type of equipment required for the work when pre-qualifying welders or welding operators.

Accomplish welding in accordance with AWS D2.0, Specifications for Welded Highway and Railway Bridges. Joint details shall be in accordance with design requirements and detail drawings. Do not alter the joint locations without written approval from the Engineer. Prepare the joint edges by sawing, machining, clipping, shearing, or gas tungsten-arc or gas metal-arc cutting. Cut surfaces shall meet the American Standards Association surface roughness rating value of one thousand (1,000). Oxygen fins, tears, and other defects which would adversely affect the quality of the weld will not be permitted. Remove dirt, grease, forming or machining lubricants, or any organic materials from the welding areas by cleaning with a suitable solvent or by vapor degreasing.

Remove the oxide on all welding edges and surfaces immediately before welding using mechanical methods such as stainless steel wire brushing, rubbing with steel wool or abrasive cloth, scraping, filing, rotary planing, or sanding. For aluminum applications, do not use wire brushes previously used on materials other than aluminum. When mechanical methods of oxide removal on aluminum materials are unsuccessful, accomplish removal of aluminum oxide using a chemical treatment detailed in Table 69.32 of the AWS and Aluminum Association Welding Aluminum Pamphlet. Perform welding within twenty-four (24) hours after chemical treatment. Use a chemical oxide remover on all welded edges and surfaces before using gas tungsten-arc welding with direct current, straight polarity. Do not weld anodically treated aluminum without removing the anodic coating from the welded joint area.

Chip or machine out the initial weld root on all butt welds requiring one hundred (100) percent penetration, except those constructed using backing, before starting welding from the second side. Thoroughly fuse the backing to the weld metal on all butt welds constructed using backing. Where accessible, backing for welds that are subject to computed stress or which are exposed to view on the completed structure and which are not otherwise parts of the structure shall be removed and the joints ground or machined smooth. In tubular members, construct butt welds subject to computed stresses using permanent backing rings or strips. Use the same procedure for production welding of any particular joint as was used in the procedure qualification for that joint.

Prepare a sample joint and macro-etched cross section of the weld when the welded joint requires a specific root penetration to demonstrate that the proposed joint welding procedure will achieve the required root penetration. The minimum length of the sample joint shall be one (1) foot. Weld the sample joint using the electrode, polarity amperage, voltage, speed, gas mixture, and gas flow rate proposed for production welding. The allowable variation of amperage and voltage shall be ten (10) percent for amperage and minus seven (7) percent for voltage during fabrication. The Engineer reserves the right to accept evidence on record in lieu of providing a sample weld.

Limit undercutting depths to less than or equal to one-hundredth (0.01) inch when the undercutting direction is transverse to the primary stress in the undercut part. Limit undercutting depths to less than or equal to one-thirty-second ($^1/_{32}$) inch when the undercutting direction is parallel to the primary stress in the undercut part. Do not overlap welds. Fill all craters to the full cross section of the welds.

Protect all shop or field welding operations from air currents or drafts to prevent any loss of gas shielding during welding. Provide adequate gas shielding to protect the molten metal during solidification. Position the work for flat position welding whenever practicable. Weld only dry joints. Use a suitable electrode size, voltage, amperage, welding speed, gas, or gas mixture, and gas flow rate for the material thickness, joint design, welding position, and other circumstances affecting the work. Gas metal-arc welding shall be done with direct current, reverse polarity. Gas tungsten-arc welding shall be done with alternating current or with direct current straight polarity.

Where preheat is needed, the temperature of preheat shall not exceed three hundred fifty (350) degrees Fahrenheit for heat-treated alloys and six hundred (600) degrees Fahrenheit for non-heat-treated alloys. Measure the temperature of the preheat using temperature-indicating crayons or pyrometric equipment. Do not hold heat-treated alloys at the maximum preheat temperature or at temperatures near the maximum for more than thirty (30) minutes.

The Engineer reserves the right to inspect the weld by any standard method. Cracks in welds or adjacent base metal and copper inclusions are unacceptable. Limit porosity to the maximum limit specified in Appendix IV, Section VIII of the ASME Boiler and Pressure Vessel Code. The Engineer may accept small and well-dispersed occurrences of lack of fusion, incomplete penetration, or tungsten or oxide inclusions only at the discretion of the Engineer.

For truss structures, use the dye penetrant test method on the following welds:

- Butt welds in columns and main chord members
- Fillet welds connecting column to bases and main chord members, including the associated flanges, gussets, or main load carrying brackets or members
- Fillet welds connecting flanges to the main truss chord members.

Perform dye penetrant tests in accordance using Method B, Procedure B-2 or B-3 as defined by ASTM E165, Standard Methods for Liquid Penetrant Inspection, in the presence of the Engineer and at no additional cost to the City.

Repair defective welds in a manner acceptable to the Engineer. Remove cracks in welds or the base metal throughout the entire length and depth and reconstruct the weld. Remove sections of the weld demonstrating excessive porosity, lack of fusion, or copper or tungsten inclusions and reconstruct the weld. Clean the weld and deposit additional weld metal when an excessive concavity of crater, undercut, or undersized weld occurs. Reduce overlapping by removing the excess weld metal. Remove defective areas by chipping or machining. Do not use oxygen-cutting. Inspect the chipped or machined area to verify that the entire defective weld has been removed before reconstructing the weld. Remove any traces of dye penetrant using solvent, water, heat, or other means acceptable to the Engineer before welding.

(E) Steel Welding.

Pre-qualify all proposed joint welding procedures. Submit the joint description or preparation, welding process, preheat and other heating requirements, welding position, amperage, voltage, polarity, welding speed, wire and flux or electrode type, type of welder, and any other related information to the Engineer for pre-qualification. Pre-qualification does not waive any requirements for producing welds that conform to the Contract Documents.

All welders, operators, and tackers shall be competent, properly trained, experienced, and capable of producing reliable welds. Certify all welders, welding operators, and tackers engaged in the work in accordance with AWS D2.0, Specifications for Welded Highway and

Railway Bridges. Submit a certificate for each welder, operator, or tacker. The certificate shall state the following:

- Name of the welder, operator, or tacker
- Name and title of the individual issuing the certification
- Arc welding process, the welding position
- Qualification positions
- Groove or fillet weld
- Limited or unlimited plate thickness
- AWS electrode and flux or electrode classification
- Date and results of the test
- Evidence that the welder, operator or tacker has repeatedly performed satisfactory welding using the required process within three (3) months of starting the work
- Any other pertinent information

A private laboratory or state highway department recognized and accepted by the Engineer shall perform all testing. Perform testing on the weld metal deposited by each automatic welding machine in accordance with the procedure qualification for fillet weld soundness, AWS D2.0, Specifications for Welded Highway and Railway Bridges. Notify the Engineer of the time and location of the testing a minimum of forty-eight (48) hours before commencing testing. The Engineer reserves the right to observe the qualification testing. The Engineer reserves the right to accept evidence of previous qualification of the welders, welding operators, or tackers.

Accomplish welding by the shielded metal-arc, submerged arc, gas metal-arc, or flux cored arc process. All welding shall conform to the requirements set forth in AWS D2.0, Specifications for Welded Highway and Railway Bridges.

The minimum preheat and interpass temperature shall be fifty (50) degrees Fahrenheit for all steels with a maximum thickness of three-fourths (¾) inch and welded using low hydrogen electrodes, or with submerged arc, gas metal arc, or flux cored arc welding.

Welding of steel to remedy other than minor defects shall be permitted only with the written approval of the Engineer.

(F) Foundation Construction.

Construct reinforced PCC foundations to the sizes and dimensions indicated in the Contract Documents. Dig or bore holes to the lines and depth specified in the Contract Documents for the construction of the foundation. Construct forms for the upper two (2) feet of the metal pole foundation. The excavation shall be dry and free of any loose materials before placing PCC. Level and secure all forms to the satisfaction of the Engineer before commencing PCC placement.

Forms shall be wood, metal, or seamless laminated fiber tubes acceptable to the Engineer. Construct forms to be mortar-tight and rigid to prevent distortion due to pressure created by PCC construction. Do not use aluminum forms.

Supply and install a driven ground rod(s) with each foundation as indicated in the Contract Documents before commencing PCC placement. The ground rod shall extend a minimum of eight (8) inches above the finished foundation and a minimum of eight (8) feet beneath the bottom of the foundation. Install the ground rod in accordance with NEC Article 250.

Install and secure all reinforcing steel and conduit in a manner acceptable to the Engineer. Conduit bends shall be ninety (90) degrees and shall exit the foundation a minimum of thirty (30) inches below the level of the surrounding ground. Plug the ends of the conduit before commencing PCC placement. Install pre-formed expansion joint material between the pole foundation and any abutting PCC structure.

Provide all equipment, labor, and tools necessary to perform the work to the satisfaction of the Engineer. The National Ready Mixed Concrete Association shall certify that the production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

Place the PCC continuously in horizontal layers not exceeding eighteen (18) inches. Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows placement operations to continue as uninterrupted as possible. Place PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Do not allow the PCC to drop more than five (5) feet from the end of the discharge chute. Use a metal pipe or channel to deliver PCC at depths greater than five (5) feet. Handle the PCC in a manner that minimizes segregation.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

During cold weather periods, place PCC only when the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature falls below forty (40) degrees Fahrenheit. Do not place PCC on frozen materials.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements. Do not

place PCC at night without the Engineer's permission. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

Consolidate the PCC throughout the length of the foundation by inserting and withdrawing a vibrator(s) at a minimum of four (4) locations within the foundation. Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC. Do not drag the vibrator through the PCC. Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

Finish the top of the foundation to be approximately one (1) inch above the adjacent ground or structure unless otherwise indicated in the Contract Documents. Finish the top of the foundation to be equal with the surrounding sidewalk elevation when constructing a foundation within the limits of a sidewalk.

Protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds for a minimum of three (3) days. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer.

Remove forms as soon as practicable after the PCC has hardened without damaging the PCC. Remove any PCC surface irregularities exposed by the removal of the forms by sanding or filling with mortar in a manner acceptable to the Engineer.

Backfill the excavation and restore any areas disturbed by the foundation construction. Backfill the foundation with lean clay or silty clay materials compacted to ninety-five (95) percent of the maximum density determined in accordance with ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

(G) Structure Installation.

Dress the PCC foundation to provide for proper seating of the bases before the erection of the vertical end frames. For aluminum structures, use an aluminum-filled, resilient sealing compound that completely covers all areas of aluminum that may contact the concrete. Do not erect the end frames more than twenty-four (24) hours in advance of installing the truss. Erect the end frames and plumb using leveling nuts. Securely tighten the top nuts to the base plate. Install the end frames in a manner that allows placement of approximately one and one-half (1½) inches of grout under the base plate.

Assemble the truss sections in the field. Adjust the truss sections using shims to provide the camber required by the Contract Documents. Install the truss on the end frames as a single piece.

Place grout between the vertical end frame base plates and the PCC foundation after completing erection of the structure. The grouting material shall be a non-shrinking grout comprised of a mixture of cement, sand, and a non-shrinking, non-ferrous additive. Rod the grout into place to eliminate voids. Do not place the grout until completion of the truss installation in its final position.

Install a No. 6 AWG stranded green insulated copper conductor attached to the ground rod using an approved clamp and connected to the grounding lug on the vertical end frame when required by the Contract Documents. Ground the structure in accordance with the NEC, local ordinances, all applicable codes, and the requirements of the local utility company supplying electrical power. The Engineer shall resolve any discrepancies. The maximum measurable resistance between the ground rod and a test stake driven two (2) feet into the ground adjacent to the PCC foundation shall not exceed twenty-five (25) ohms. If the resistance exceeds twenty-five (25) ohms, install additional ground rods greater than six (6) feet apart and connected using a No. 4 AWG bare copper wire. The number of additional ground rods shall be as needed to produce a measurable resistance of less than twenty-five (25) ohms.

902.04 Method of Measurement and Basis of Payment

The Engineer shall measure truss structures for payment as a single unit furnished, installed, and accepted.

The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of any foundation design associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of the tree or shrub trimming is subsidiary to items for which the Contract provides direct payment. Loading, hauling, construction of all materials, mounting hardware and sign brackets, junction boxes, additional grounding rods, horizontal and vertical wiring for the structure, and all miscellaneous hardware is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents. Any costs associated with installing wire/conduit into an existing base/foundation/pad, joint welding procedure pre-qualification, or welders, welding operators, or tackers certification are subsidiary to items for which the Contract provides direct payment. Costs associated with surface restoration are subsidiary to items for which the Contract provides direct payment. Replace any damaged signs at no additional cost to the City.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This contract price shall include furnishing, fabricating, welding, delivery and erection of the box truss, center mount supports, cantilever sign supports or sign brackets attached to an existing bridge, PCC foundations, reinforcing steel, anchor bolts, electrical conduit, concrete, PCC forms, PCC placement and curing, grout and grouting, vertical end frames, catwalks and handrails, aluminum beams for vertical sign supports, hardware for attaching beams to the box trusses, for all welder qualifications testing connected with the work; for furnishing and installing the sign illumination system; for convenience outlet and other electrical equipment; for all equipment, materials, tools, labor and incidentals necessary to complete the work; but this shall not include the material and labor required for the laying of the closed conduit electrical system feeding the system.

Description	**Unit**
Truss Structure, *(location)*	Each

THIS PAGE INTENTIONALLY LEFT BLANK

903 – SIGNALS AND LUMINAIRES

903.01 Description.

This includes the furnishing and installing of traffic signals and luminaires on span wire poles, mast arm poles, combination mast arm and lighting poles, and pedestal poles including all materials, equipment, labor, tools, transportation, permits, licenses, and all other miscellaneous items necessary to provide an operable system required by the Contract Documents.

903.02 Material Requirements.

(A) Conventional Traffic Signals.

Traffic signal heads shall be black polycarbonate sections meeting the requirements of Chapter 2, Vehicle Traffic Control Signal Heads, ITE publication number ST-0017A, Equipment and Material Standards of the ITE. The traffic signal head body, doors, visors, and back plates shall be black. Impregnate the coloring into the polycarbonate material such that scratches do not expose non-black material. All sections shall be interchangeable and fit to allow combining in a tier.

Signal heads shall allow visors to attach using screws such that the installation or removal of the visor does not require modification to the signal head or special tools. Install visors around each traffic signal module. Use tunnel-type visors having a minimum circumference of seventy-five (75) percent of the traffic signal module lens circumference for all non-optically programmed sections. Use a cutaway-type visor acceptable to the Engineer for all optically programmed sections.

Mount a terminal block on the back of the second section of the signal head. The terminal block shall be a four (4) position, eight (8) terminal barrier-type strip. Mount the terminal block in accordance with the manufacturer's instructions.

Doors shall be weather-tight. Hinges shall use enclosed, solid, non-corrosive, metallic hinge pins. Doors shall secure using wing nut clamps or other securing mechanisms acceptable to the Engineer.

Equip traffic signal heads with back plates as required by the Contract Documents. Back plates shall consist of a one (1) piece, vacuum-formed, ABS plastic plate having a minimum thickness of one-eighth ($^1/_8$) inch and a flange wall on all sides with a minimum thickness of five-eighths ($^5/_8$) inch. Install back plates in accordance with the manufacturer's instructions.

Incandescent traffic signal indicators shall meet the requirements of Chapter 2, Vehicle Traffic Control Signal Heads, ITE publication number ST-0017A, Equipment and Material Standards of the ITE, and

the additional requirements contained herein. The incandescent lamp shall meet the required wattage for 120/125 volt operation and have a rated life of sixteen thousand (16,000) hours. The filament design shall be C-11V using two (2) lead and five (5) hook filament supports. The lamp shall have a crystal-clear finish and a grooved base cemented to a 102 medium brass base. The lamp shall be gas-filled. The gas filling shall consist of ninety-five (95) percent krypton and five (5) percent nitrogen. Provide independent laboratory verification of the gas filling upon request by the Engineer at no additional cost to the City.

Light Emitting Diode (LED) traffic signal indicators shall meet the requirements of Chapter 2, Vehicle Traffic Control Signal Heads, and Chapter 2a, VTCSH Part 2: Light Emitting Diode (LED) Vehicle Signal Modules, ITE publication number ST-0017A, Equipment and Material Standards of the ITE. LED traffic signal indicators shall conform to the Federal Communication Commission (FCC) requirements for noise generation.

Unless otherwise indicated in the Contract Documents, all red and green traffic signal indicators shall be LED signal indicators except for optically programmed signal heads.

Use the same model and manufacturer for each size of incandescent traffic signal indicators. Use the same model and manufacturer for each size of LED traffic signal indicators.

(B) Optically Programmed Traffic Signals.

Optically programmed traffic signals shall consist of a signal head, objective lens, optical limiter-diffuser, lamp, and lamp collar. The optical system shall accommodate projection of diverse, selected identifying marks to separate portions of the roadway such that only one indication will be simultaneously apparent to any viewer. The projected indication shall conform to the transmittance and chromaticity standards of Chapter 2, Vehicle Traffic Control Signal Heads, ITE publication number ST-0017A, Equipment and Material Standards of the ITE.

Design optically programmed traffic signals to meet the following requirements:

- Determine the visibility zone of the signal optically without louvers or shields.
- Allow the selective veiling of the projected indication anywhere within fifteen (15) degrees of the optical axis.
- Mount as a single section, a multiple section, or in combination with other signals.
- Incorporate a standard one and one-half (1½) inch fitting.
- Allow incremental tilting through an adjustable connection for a range of zero (0) to ten (10) degrees while maintaining a

common horizontal and vertical axis through couples and mountings.

- Allow external adjustment about the mounting axis in five (5) degree increments through the terminal connection.
- Special tools shall not be required for mounting, and service shall be possible without tools.
- Attaching visors, back plates, and adapters shall not affect the light and water integrity of the signal.

Die cast aluminum parts shall conform to the alloy and tensile requirements, chromate preparatory treatment, and optical black paint requirements outlined in Chapter 2, Vehicle Traffic Control Signal Heads, ITE publication number ST-0017A, Equipment and Material Standards of the ITE. Hinge and latch pins shall be stainless steel. Finish the exterior of the signal case, lamp housing, and mounting flanges with a high quality baked enamel prime and finish paint. The signal head, body, doors, visors, and back plates shall be optical black. Seal all access openings with weather resistant rubber gaskets. Provide a drain hole in each head at the lowest point.

Pre-drill the signal case and lens holder to allow installation of back plates and visors. Signal heads shall allow visors to attach using screws such that the installation or removal of the visor does not require modification to the signal head or special tools. Install a cutaway-type visor acceptable to the Engineer around each traffic signal module. Back plates shall consist of a one (1) piece, vacuum-formed, ABS plastic plate having a minimum thickness of one-eighth ($^1/_8$) inch and a flange wall on all sides with a minimum thickness of five-eighths ($^5/_8$) inch. Install back plates in accordance with the manufacturer's instructions.

The objective lens shall consist of a high-resolution planer incremental lens hermetically sealed within a flat laminate of weather resistant acrylic or approved equal. Design the objective lens to allow ninety (90) degree rotation about the optical axis without displacing the primary image.

Design the convex surface of the optical limiter to discretely or integrally incorporate the diffusing element. Provide heat resistant glass and a position indexing means for the optical limiter. Design the optical limiter to focus objects on the optical axis and provide an accessible image to objects within the range of ninety (90) feet to one thousand two hundred (1,200) feet. The optical limiter shall permit the application of an effective veiling mask to determine the visibility zone.

The lamp shall consist of a one hundred fifty (150) watt sealed beam lamp rated for an average life of at least six thousand (6,000) hours, and operating at a nominal voltage of 120 volts AC. Each lamp shall

illuminate only one lens and no indications shall result from any external illumination.

The lamp collar shall consist of an integral lamp support in a separately accessible housing, a quick-release lamp retainer that is self-aligning, and an indexed ceramic socket. Incorporate an interlock assembly that disconnects the lamp holder between the lamp housing and the case. Install terminal blocks on all wire terminations coming into the signal. Interconnect all sections using No. 18 AWG stranded and coded wires.

(C) Pedestrian Symbols.
Pedestrian symbols shall be McCain Traffic Supply Model M23970 or approved equal. The minimum symbol height shall be nine (9) inches. Use a minimum of a sixty-nine (69) watt bulb unless otherwise specified by the manufacturer. Use LED Pedestrian "Don't Walk" symbols unless otherwise indicated in the Contract Documents. The Engineer reserves the right to reject for any reason a select product or group of products from an LED symbol manufacturer.

(D) Pedestrian Signal Housing.
Pedestrian signal housing shall be black polycarbonate. Impregnate the coloring into the polycarbonate material such that scratches do not expose non-black material.

(E) Pedestrian Pushbutton.
Pedestrian pushbuttons shall be black in color and of the type and style specifically indicated in the Contract Documents. House pedestrian pushbuttons in a durable, weather-tight casting. Design the button and mechanisms to withstand abuse and vandalism. Design the internal switching device to close by physical contact with the button. Cover the button with a rubber cover boot. Include pushbutton signs with push button. The signs shall conform to codes R10-4-6 and R10-4-7 of the current version of the City of Omaha Sign Book. Supply the type of sign indicated in the Contract Documents including arrows if directed.

(F) Mounting Hardware.
Mounting hardware shall conform to the pole manufacturer's requirements for the load and type of mounting required.

(G) Luminaire Head.
Unless otherwise indicated in the Contract Documents, Omaha Public Power District shall supply the luminaire head.

(H) Grounding Wire.
Grounding wire shall be No. 6 AWG stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire. Copper grounding wire installed in conduit shall be No. 6 AWG

green insulated stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire.

(I) Bonding Clamps.
Bonding clamps shall be galvanized metal clamps that expand by tightening a set screw. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

(J) Splice Boxes.
Splice boxes shall conform to the applicable NEMA requirements for the installation and use required.

(K) Conduit.
Conduit and conduit fittings shall be galvanized rigid steel conforming to UL-6, UL Standard for Safety for Electrical Rigid Metal Conduit – Steel; high-density polyethylene conforming to ASTM F2160, Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD); or rigid polyvinyl chloride conforming to UL-651, UL Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit. Furnish in standard lengths with UL label. Rigid steel conduit fittings shall be galvanized steel or galvanized malleable iron. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. PVC conduit fittings and cement shall be compatible with the PVC conduit. Conduit size shall be the minimum trade size permitted for the application. Conduit installed for above ground risers shall be galvanized rigid steel conduit.

(L) Traffic Signal Cable.
Traffic signal cable shall be No. 14 AWG solid wire traffic signal cable with the number of conductors indicated in the Contract Documents. Traffic signal cable shall comply with IMSA Specification 20-1, Specification 20-2, and Specification 20-3. Color code conductors using coloring that penetrates the full thickness of the conductor insulation. Do not color-code using only printed words or numerals on the exterior of the conductor insulation.

(M) Push Button Lead-in Cable.
Push Button Lead-in cable shall be No. 16 AWG solid wire traffic signal cable with the number of conductors indicated in the Contract Documents. Push Button Lead-in cable shall comply with IMSA Specification 20-1, Specification 20-2, and Specification 20-3. Color code conductors using coloring that penetrates the full thickness of the conductor insulation. Do not color-code using only printed words or numerals on the exterior of the conductor insulation.

(N) Service Cable: Types SC, SEC and 3/C.

Service Cable for the power source circuits shall be Type THWN copper conductor, gasoline and oil resistant, 600 Volt AWG. Service cable wire shall be black in color and the neutral wire # 6 AWG or smaller shall be white. The cable installation shall conform to the requirements of Article 310 of the National Electric Code. The Service Cable is to run from the power source to the controller.

The Engineer shall size cables from the transformer to the Service Disconnect, referred to as Service Conductors (SC), and cables from the Service Disconnect, referred to as Service-Entrance Conductors (SEC), to meet field conditions.

Cables installed for streetlight luminaries, referred to as 3-conductors (3/C), shall be # 6 AWG wire.

(O) Communication Cable.

Copper-twisted pair communication cable shall be No. 22 AWG solid wire and shall meet the requirements of REA Specification PE-39 and IMSA Specification 60-6. The cable shall contain the number of pairs specified in the Contract Documents. Fiber-optic communication cable shall meet the requirements of ISMA Specification 70 and the specified requirements in the Contract Documents.

903.03 Construction Requirements.

(A) General.

Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 903.01 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents. At the time of each submittal, identify in writing any deviations that the shop drawings or samples may have from the requirements of the Contract Documents.

Table 903.01
Materials Information Requirements

Item	Required Information
Traffic Signals	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance
Optically Programmed Traffic Signals	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance
Incandescent Signal Lamps/Bulbs	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance
LED Signal Indicators	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance
Pedestrian Signals	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance
Mounting Hardware	Manufacturer's Model or Catalog Number, Working Drawing*
Electrical Cable	Manufacturer's Model or Catalog Number, Certificate of Compliance
Pedestrian Push Buttons	Manufacturer's Model or Catalog Number
Conduit	Manufacturer's Model or Catalog Number
Splice Boxes	Manufacturer's Model or Catalog Number

* As required by the Engineer

Before ordering structural steel, locate overhead or underground utilities to verify that they do not interfere with the work outlined in the Contract Documents. Order all poles, mast arms, span wires, anchors, and related materials necessary to complete the work no later than ten (10) calendar days after receiving approval of the submitted materials information. Submit proof of the orders and estimated delivery time to the Engineer within fifteen (15) calendar days after receiving approval of the submitted materials information. Identify any materials already in possession. Do not substitute items without written permission from the Engineer. Do not construe Engineer's acceptance of a submittal as relieving the Contractor of the responsibility to comply with the Contract Documents.

Obtain all licenses and permits before commencing the work.

A competent worker experienced in the required work shall perform all work under the supervision of a licensed journeyman electrician or lineman. A qualified journeyman electrician or lineman shall directly supervise any work involving the installation of cable, foundations, structural steel, and traffic control equipment. Wire all circuits as required by the Contract Documents, clear of faults, grounds, and open circuits. Connect the service neutral conductor and all interconnected equipment grounding conductors solidly to a driven ground rod at the traffic signal service disconnect pedestal. Installations shall comply with all applicable sections of the National Electrical Code, National Electrical Safety Code, Manual on Uniform Traffic Control Devices, all governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Inform the Engineer of the work scheduled each day. Schedule work to minimize the time any signal is inoperable. During this time, provide, place, and maintain temporary traffic control devices in accordance with the City of Omaha's "Manual of Barricading Standards, Specifications, Methods, and Materials". Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Provide the utility company supplying the electrical service adequate notice regarding the scope and nature of the power requirement. Arrange for all necessary electrical services at locations indicated in the Contract Documents. The utility company or Engineer may alter the service location in the field to adapt to certain field requirements. Cooperate with the utility company providing electrical service in locating the service lines and conduit bends.

Trim trees or shrubs using proper tree surgery practices to trim tree branches as necessary to install the poles, mast arms, span wires, or pole. Use an asphaltum-based paint manufactured for tree surgery to treat the cut or scarred branches.

Do not disconnect or damage an operational communication cable while performing work around traffic signal systems without written permission from the Engineer. Reconnect, repair, or establish a temporary connection within eight (8) hours of disconnecting or damaging a communication cable.

Size conduit bends installed in existing foundations to be equivalent to the connecting conduit in the ground. Do not cut or damage the reinforcing steel or anchor bolts in the foundation. Install the conduit a minimum depth of twelve (12) inches below the top of the foundation or thirty (30) inches below the depth of the surrounding ground surface, whichever is greater. Remove a sufficient amount of concrete to place the conduit inside the anchor bolts of the foundation. Position the conduit and place concrete or grout. Finish to match the existing foundation.

Replace or restore in kind equal to or exceeding any surface materials disturbed by trenching, excavating, or backfilling operations. Accomplish restoration in accordance with the Contract Documents. Dispose of all excess materials as directed by the Engineer.

Neatly route cables to their destinations in cabinets, pole bases, pull boxes, and all other terminations. Submit to the Engineer and follow all manufacturer-recommended values for the allowable bending radii for permanent routing during installation. Connect cables at the control cabinet using terminal boards provided for this purpose. Equip each stranded wire inserted under a binder screw with a solderless, pressure-type spade connector with a pre-insulated shank. Do not use more than one (1) stranded wire with each spade connector. Do not insert more than three (3) spade connectors under a single binder screw unless otherwise indicated in the Contract Documents or directed by the Engineer. Do not use a spade connector when terminating solid conductor wires. Insert only one (1) solid conductor wire under a binder screw.

Drill cable inlet holes in the field as necessary at locations acceptable to the Engineer. Cables coming out of the mast arm pole and entering the mast arm shall have adequate drip loops. Cables coming out of the mast arm and going into the signal heads shall have adequate drip loops.

Activate and operate the system in normal fashion as soon as possible if the road is open to public travel at the time the installation or any workable segment of the installation is completed. Notify the Engineer a minimum of forty-eight (48) hours before putting the system into operation. Do not put the system into operation without the Engineer present. Secure the services of a person qualified to operate and adjust the system. Test the circuits installed before activating the system.

Before final acceptance, demonstrate by tests to the Engineer's satisfaction that all electrical installations are in proper condition as required by the Contract Documents. Do not construe operation of the system as acceptance of the system, acceptance of any part of the system, or as a waiver of any contract provisions. All electrical installations are subject to a thirty (30) day trial period before the Engineer may consider the installation for acceptance. The City shall pay for electrical energy consumed by the system during the thirty (30) day operational trial period. Transfer any guarantees or warranties on materials purchased to the City upon acceptance of the work. Purchase materials with transferable guarantees or warranties.

After the system is turned on and operating satisfactorily, the City shall assume responsibility for routine maintenance. Maintenance activities by the City do not relieve the Contractor of any responsibility for failures due to workmanship or materials that occur before final acceptance of the project. The Engineer shall decide the responsibility of the Contractor relating to any failure occurring before final acceptance.

(B) Traffic Signal Installation.

Install traffic signals as shown in accordance with the manufacturer's recommendations and the Contract Documents. Erect each signal assembly to be plumb and securely attached with all fittings tight. Repair any scratches or mars in the paint in a manner acceptable to the Engineer. Install all accessories in accordance with the manufacturer's recommendations. Route the traffic signal and grounding cable to the pole base. Install the traffic signal lamps in a manner to provide maximum brightness and visibility without hotspots.

If the roadway is open to public travel and the erected signal system is not in operation, mask the signals using materials acceptable to the Engineer. Cover all inoperative signals on a road open to the public without exception. Upon removal, the covering shall remain the property of the Contractor.

Connect the service neutral conductor and all interconnected equipment grounding solidly to a driven ground rod at the traffic signal service disconnect pedestal. Route service conductors from the power source to the service disconnect then to the controller. Provide a minimum of 5 (five) feet of excess wire at each end to allow for final connection without splicing.

(C) Pedestrian Signal Installation.

Install pedestrian signals as shown in accordance with the manufacturer's recommendations and the Contract Documents. Erect each signal assembly to be plumb and securely attached with all fittings tight. Repair any scratches or mars in the paint in a manner acceptable to the Engineer. Install all signs and accessories in accordance with the manufacturer's recommendations. Route the pedestrian push button lead-in cable to the pole base.

(D) Luminaire Installation.

Install luminaires as shown in accordance with the manufacturer's recommendations and the Contract Documents. Erect each luminaire assembly to be plumb and securely attached with all fittings tight. Repair any scratches or mars in the paint in a manner acceptable to the Engineer. Install all accessories in accordance with the manufacturer's recommendations. Route the luminaire cable to the pole base. Provide a minimum of thirty-six (36) inches of excess luminaire cable extending beyond the end of the luminaire mast arm.

903.04 Measurement and Payment.

The Engineer shall measure traffic signals for payment as single units constructed and accepted.

The Engineer shall measure the installation of existing or supplied traffic signals for payment as single units installed and accepted.

The Engineer shall measure pedestrian signals for payment as single units constructed and accepted.

The Engineer shall measure pedestrian push buttons for payment as single units constructed and accepted.

The Engineer shall measure the installation of existing or supplied pedestrian push buttons for payment as single units installed and accepted.

The Engineer shall measure the installation of service cable for payment as the number of linear feet of service cable installed and accepted disregarding any slacking or splicing.

The Engineer shall measure the installation and removal of a wood pole for temporary pedestrian signals for payment as a lump sum unit defined by a wood pole installed, removed, and accepted.

The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of the tree or shrub trimming is subsidiary to items for which the Contract provides direct payment. Loading, hauling, construction of all signals and luminaires, pedestrian pushbutton signs and accessories, mounting hardware, and all miscellaneous hardware is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents. Any costs associated with installing wire/conduit into an existing base/foundation/pad are subsidiary to items for which the Contract provides direct payment. Any costs associated furnishing and installing temporary coverings are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Traffic Signal, Type TS-___ with ___ Face, ___, and ___ Mounting	Each
Install Traffic Signal	Each
Pedestrian Signal, Type PS-___, ___ Face, and ___ Mounting	Each
Pedestrian Push Button	Each
Install Pedestrian Push Button	Each
Service Cables (SC, SEC, 3/C)	Linear Feet
Set And Remove Wood Pole For Temporary Pedestrian Traffic Signal	Lump Sum

THIS PAGE INTENTIONALLY LEFT BLANK

904 – TRAFFIC SIGNAL CONTROLLERS

904.01 Description.

This work includes furnishing and installing pole-mounted and pad-mounted traffic signal including all materials, equipment, labor, tools, transportation, permits, licenses, and all other miscellaneous items necessary to provide an operable system as required by the Contract Documents.

904.02 Material Requirements.

(A) General.

Traffic signal controllers shall comply with FHWA IP-78-16, General Specifications for Traffic Signal Equipment dated December 1978 and the Contract Documents. The Engineer shall resolve any conflicts. Provide all traffic signal controller equipment documentation as specified in the Traffic Signal Equipment Specifications published by the State of California Business, Transportation, and Housing Agency.

(B) System Memory Prom Module.

System memory prom modules shall meet the requirements for a Model 170 Traffic Prom Module as defined by FHWA IP-78-16, General Specifications for Traffic Signal Equipment. Route electrical connections though the module using a printed circuit connector having two (2) rows of thirty-six (36) independent bifurcated contacts placed on one-tenth (0.1) inch centers. Design the module to facilitate removal or installation without requiring personnel to insert hands or fingers into the microprocessor unit housing. Attach a handle or gripping device protruding one and one-fourth (1¼) inches or less from the front panel of the module. Design the module with a positive method for preventing improper installation into the prom slot. Connect the front panel to the ground.

All data inputs and outputs shall be Tri State Buffered enabling them to drive a load consisting of ten (10) transistor logic gates and two hundred (200) picofarads. Disable the data output and inputs into a high impedance state when not addressing the module. The data input/output lines shall not source or sink more than one hundred (100) microamperes. All address inputs shall not load the bus by more than one (1) transistor logic gate load and one hundred (100) picofarads.

The memory shall consist of a minimum of three (3) twenty-eight (28) pin sockets. Use jumper shunts or soldered wires to select EPROM usage. Do not require switches. Program any one or combination of the three (3) twenty-eight (28) pin sockets to house 62256 RAM devices. Program the pin socket(s) using jumper shunts or soldered jumper wires. Do not require switches.

RAM devices shall be NOVRAM or RAM with a lithium battery backup. Provide standby voltage for all RAM devices when used. Install one (1) blank 27256-25 EPROM and one (1) NOVRAM 256K or one (1) 62256 with a lithium battery for each system memory module. Install one (1) NOVRAM 64K or 6264 with a lithium battery for the master prom module.

The entire memory address map shall be user definable to allow for addressing the sockets independently. Provide a regulated five (5) volt power supply with a minimum of five hundred (500) milliamps derived from the twelve (12) volt supply on the prom module connector to the system memory module. The system memory module shall allow an option to add a lithium battery for volatile RAM devices. The module shall operate and inter-mate with the Model 170 Controller Unit. Label the front panel to read "System Memory."

(C) Controller.

The Controller shall be a Type 170E or 170HCII Controller, with four (4) asynchronous communications interface adapter (ACIA) ports conforming to the Type 170 Traffic Signal Controller Systems – Hardware Specifications as defined by FHWA-IP-78-16, General Specifications for Traffic Signal Equipment, and the latest revision of the California State Specification. Provide a System Memory Module with the controller as required by the Contract Documents.

(D) Controller Cabinet.

The controller cabinet provided shall be as designated on the plans designed specifically for use with the Type 170 Traffic Signal Controller. The 303, 332, 336, and 336S cabinets shall meet the latest revision of the California State Specification with the following modifications and/or additions. The controller cabinet shall be unpainted natural aluminum and equipped with a filtering surge protector, EDCO SHA1250 or pre-approved equivalent. Use a Model PDA-2 power distribution assembly or pre-approved equivalent and a Model 206 twenty-four (24) volt plug in power supply for all controller cabinets. Equip the cabinet with a surge suppressor, EDCO Model PC642C008D or pre-approved equivalent, and a female terminal connector, Buchanan Series PCB1B or pre-approved equivalent. The Type 170 controller shall plug into the one hundred twenty (120) volt power outlet designated for the Type 170 controller. Equip the controller cabinet with all 204 flashers and flash transfer relays necessary for full operation. Provide a minimum of four (4) red and four (4) yellow flash transfer plugs including the necessary mounting hardware.

(E) Conflict Monitor – Model 210.

The Model 210 Conflict Monitor shall be compatible with the Type 170 Traffic Control System and shall meet all requirements of the latest version of the Traffic Signal Equipment Specifications published by the

State of California Business, Transportation, and Housing Agency. The monitor shall identify power problems, brownouts, and power surges.

(F) Switch Pack Model 200 and Flasher Model 204.
The model 200 Switch Pack Unit and Model 204 Flasher Unit shall be compatible with the Type 170 Traffic Control System and shall meet all requirements of the latest of the Traffic Signal Equipment Specifications published by the State of California Business, Transportation, and Housing.

(G) Two Channel Isolators – Model 242 and 252.
Model 242 and 252 Two Channel Isolators shall be compatible with the Type 170 Traffic Control System and shall meet all requirements of the latest version of the Traffic Signal Equipment Specifications published by the State of California Business, Transportation, and Housing Agency.

(H) Modems – Model 404 and Auto Dial.
The Model 404 modems shall be compatible with the Type 170 Traffic Control System. The Model 404 modem shall plug directly into the modem slot provided in the 170 controller and shall meet all requirements of the latest version of the Traffic Signal Equipment Specifications published by the State of California Business, Transportation, and Housing Agency. The modem shall have an operating temperature range between minus twenty (-20) and one hundred thirty (130) degrees Fahrenheit. The auto dial modem shall be a 56000 kilobytes per second modem that plugs directly into the modem slot provided in the 170 controller. The auto dial modem shall meet all requirements of the latest version of the Traffic Signal Equipment Specifications published by the State of California Business, Transportation, and Housing Agency. Configure the auto dial modem to reset automatically when disconnected by anything other than a command from a controlling computer. The modem must have an operating temperature range between minus (-20) and one hundred (130) degrees Fahrenheit.

(I) Telephone Lines.
Telephone lines shall be a No. 22 AWG six (6) pair cable color coded in accordance with IPCEA and conforming to the requirements of REA specification PE-39.

(J) Conduit and Conduit Fittings.
Conduit and conduit fittings for direct bury applications shall be galvanized rigid steel conforming to UL-6, UL Standard for Safety for Electrical Rigid Metal Conduit – Steel; high-density polyethylene conforming to ASTM F2160, Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD); or rigid polyvinyl chloride conforming to UL-

651, UL Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit. Conduit and conduit fittings for boring applications shall be high density polyethylene conforming to ASTM D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter. Furnish in standard lengths with UL label. Rigid steel conduit fittings shall be galvanized steel or galvanized malleable iron. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. PVC conduit fittings and cement shall be compatible with the PVC conduit. Transitions between HDPE and PVC conduits shall conform to the manufacturer's recommendations. Conduit size shall be the minimum trade size permitted for the application. Conduit installed for above ground risers shall be galvanized rigid steel conduit.

(K) Grounding Wire and Grounding Rods.

Copper grounding wire shall be No. 6 AWG stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire. Copper grounding wire installed in conduit shall be No. 6 AWG green insulated stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire. Grounding rods shall comply with IMSA Specification Number 62-1956 excluding length and diameter requirements. Ground rods shall have a minimum diameter of five-eighths ($^5/_8$) inch. Supply ground rods and test stakes with a ground rod clamp.

(L) Aggregate for Base.

Aggregate for base shall meet the requirements of ASTM D2940, Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports.

(M) Portland Cement.

Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3.

(N) Water.

All water used in PCC shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(O) Aggregate.

Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all

requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(P) Admixtures.

Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC.

Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(Q) PCC Mix Proportioning.

Proportion PCC mixtures to meet the requirements of Table 904.02.

Table 904.02
PCC Properties

Mix Type	L6
Portland Cement Content, lbs. per cubic yard	564
Coarse Aggregate, % of Total Aggregate	30±3
Fine Aggregate, % of Total Aggregate	70±3
Maximum Water Cement Ratio	0.45
Minimum 28-Day Compressive Strength, psi	3500
Air Content, %	6.5±1.0
Slump, inches	4-inch Max.
Concrete Temperature during placement, °F	70±25

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete

- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(R) Reinforcing Steel.
Reinforcing steel shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

(S) Curing Materials.
Curing materials shall be membrane-forming compounds or polyethylene film. Liquid membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete. Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete

904.03 Construction Requirements.

(A) General.
Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 904.03 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents. At the time of each submittal, identify in writing any deviations that the shop drawings or samples may have from the requirements of the Contract Documents.

Table 904.03
Materials Information Requirements

Item	Required Information
System Memory Module	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance, Mill Test**, Design Calculation**
Conflict Monitor	Manufacturer's Model or Catalog Number, Certificate of Compliance, Mill Test**, Design Calculation**
Switch Pack	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance, Mill Test**, Design Calculation**
Flasher Pack	Manufacturer's Model or Catalog Number, Certificate of Compliance
Two Channel Isolator	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance, Mill Test**, Design Calculation**
Modem	Manufacturer's Model or Catalog Number, Certificate of Compliance
Type 170 Controller	Manufacturer's Model or Catalog Number
Traffic Controller Cabinet	Manufacturer's Model or Catalog Number, Certificate of Compliance

* As required by the Engineer
** May substitute catalog number or model number for shop drawing as permitted by the Engineer

Before ordering the controller cabinet, locate overhead or underground utilities to verify that they do not interfere with the work outlined in the Contract Documents. Order the controller, controller cabinet, related components, and related materials necessary to complete the work no later than ten (10) calendar days after receiving approval of the submitted materials information. Submit proof of the orders and estimated delivery time to the Engineer within fifteen (15) calendar days after receiving approval of the submitted materials information. Identify any materials already in possession. Do not substitute items without written permission from the Engineer. Do not construe Engineer's acceptance of a submittal as relieving the Contractor of the responsibility to comply with the Contract Documents.

Obtain all licenses and permits before commencing the work.

A competent worker experienced in the required work shall perform all work under the supervision of a licensed journeyman electrician or lineman. A qualified journeyman electrician or lineman shall directly supervise any work involving the installation of cable and traffic control equipment. Wire all circuits as required by the Contract Documents, clear of faults, grounds, and open circuits. Connect the service neutral conductor and all interconnected equipment grounding conductors solidly to a driven ground rod at the traffic signal service disconnect pedestal. Installations shall comply with all applicable sections of the National Electrical Code, National Electrical Safety Code, Manual on Uniform Traffic Control Devices, all governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Inform the Engineer of the work scheduled each day. Schedule work to minimize the time any signal is inoperable. During this time, provide, place, and maintain temporary traffic control devices in accordance with the City of Omaha's "Manual of Barricading Standards, Specifications, Methods, and Materials". Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Provide the utility company supplying the electrical service adequate notice regarding the scope and nature of the power requirement. Arrange for all necessary electrical services at locations indicated in the Contract Documents. The utility company or Engineer may alter the service location in the field to adapt to certain field requirements. Cooperate with the utility company providing electrical service in locating the service lines and conduit bends.

Trim trees or shrubs using proper tree surgery practices to trim tree branches as necessary. Use an asphaltum-based paint manufactured for tree surgery to treat the cut or scarred branches.

Do not disconnect or damage an operational communication cable while performing work around traffic signal systems without written permission from the Engineer. Reconnect, repair, or establish a temporary connection within eight (8) hours of disconnecting or damaging a communication cable.

Replace or restore in kind equal to or exceeding any surface materials disturbed by trenching, excavating, or backfilling operations. Accomplish restoration in accordance with the Contract Documents. Dispose of all excess materials as directed by the Engineer.

Neatly route cables to their destinations in cabinets, pole bases, pull boxes, and all other terminations. Submit to the Engineer and follow all manufacturer-recommended values for the allowable bending radii for permanent routing during installation. Drill cable inlet holes in the field as necessary at locations acceptable to the Engineer. Connect cables at the control cabinet using terminal boards provided for this purpose. Equip each stranded wire inserted under a binder screw with a solderless, pressure-type spade connector with a pre-insulated shank. Do not use more than one (1) stranded wire with each spade connector. Do not insert more than three (3) spade connectors under a single binder screw unless otherwise indicated in the Contract Documents or directed by the Engineer. Do not use a spade connector when

terminating solid conductor wires. Insert only one (1) solid conductor wire under a binder screw.

Activate and operate the system in normal fashion as soon as possible if the road is open to public travel at the time the installation or any workable segment of the installation is completed. Notify the Engineer a minimum of forty-eight (48) hours before putting the system into operation. Do not put the system into operation without the Engineer present. Secure the services of a person qualified to operate and adjust the system. Test the circuits installed before activating the system.

Before final acceptance, demonstrate by tests to the Engineer's satisfaction that all electrical installations are in proper condition as required by the Contract Documents. Do not construe operation of the system as acceptance of the system, acceptance of any part of the system, or as a waiver of any contract provisions. All electrical installations are subject to a thirty (30) day trial period before the Engineer may consider the installation for acceptance. The City shall pay for electrical energy consumed by the system during the thirty (30) day operational trial period. Transfer any guarantees or warranties on materials purchased to the City upon acceptance of the work. Purchase materials with transferable guarantees or warranties.

After the system is turned on and operating satisfactorily, the City shall assume responsibility for routine maintenance. Maintenance activities by the City do not relieve the Contractor of any responsibility for failures due to workmanship or materials that occur before final acceptance of the project. The Engineer shall decide the responsibility of the Contractor relating to any failure occurring before final acceptance.

(B) Traffic Signal Controller Cabinet Installation – Pole-Mounted.
Install the traffic signal controller cabinet at the location shown in accordance with the Contract Documents. Install pole-mounted units in accordance with the pole and cabinet manufacturer's recommendations.

Connect the bottom of 303 pole-mounted cabinets to the signal pole using a two and one-half (2½) inch Type LB conduit body. Connect the bottom of 336 and 336S pole-mounted cabinets to the signal pole using a three (3) inch Type LB conduit body. Field locate and install any holes for the Type LB conduit as necessary. Install the required conduit within the cabinet clear of any braces or equipment that interfere with cable runs.

(C) Traffic Signal Controller Cabinet Installation – Pad-Mounted.
Install the traffic signal controller cabinet at the location shown in accordance with the Contract Documents. Excavate to the lines and depth specified in the Contract Documents for pad-mounted controllers. Install ninety (90) degree conduit bends as required by the Contract

Documents. Plug the ends of the conduit before commencing PCC placement. Uniformly place and compact an aggregate base without causing segregation or displacing or damaging the underlying subgrade or conduit. Do not place aggregate material if the ambient air temperature is below thirty-five (35) degrees Fahrenheit. Shape the aggregate material to produce a uniform surface meeting the requirements for line and grade as required by the Contract Documents unless otherwise directed by the Engineer.

Compact the aggregate base material to a minimum of ninety-five (95) percent of the maximum density as determined by ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. Maintain the moisture content of the aggregate material in a range that facilitates achieving the required compaction.

Construct the aggregate base to a thickness within one-half (½) inch of the thickness indicated in the Contract Documents. The Engineer shall conduct thickness measurements after the Contractor has completed final grading. Correct all non-conforming areas in a manner acceptable to the Engineer. Scarify areas deficient in thickness before adding additional material. The Contractor is responsible for protecting and maintaining the constructed aggregate subbase or base. Repair any damaged areas at no additional cost to the City.

Construct forms for the PCC pad. Level and secure all forms to the satisfaction of the Engineer before commencing PCC placement. Forms shall be wood or metal. Construct forms to be mortar-tight and rigid to prevent distortion due to pressure created by PCC construction. Do not use aluminum forms.

Supply and install a driven ground rod(s) at the base of the controller cabinet as indicated in the Contract Documents before commencing PCC placement. The ground rod shall extend a minimum of eight (8) inches above the finished foundation and a minimum of eight (8) feet beneath the bottom of the foundation. Install the ground rod in accordance with NEC Article 250. Install and secure all reinforcing steel, anchor bolts, and drainage tubes in a manner acceptable to the Engineer. Install pre-formed expansion joint material between the pole foundation and any abutting PCC structure.

Install and secure all reinforcing steel and conduit in a manner acceptable to the Engineer. Center the bolt circle in the middle of the pad and set the anchor bolts plumb in the pad at a projection distance in accordance with the pole manufacturer's instructions. Conduit bends shall be ninety (90) degrees and shall exit the foundation a minimum of thirty (30) inches below the level of the surrounding ground. Plug the ends of the conduit before commencing PCC placement. Install pre-formed expansion joint material between the pad and any abutting PCC structure.

Provide all equipment, labor, and tools necessary to perform the work to the satisfaction of the Engineer. The National Ready Mixed Concrete Association shall certify that the production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or embedded items, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

Place the PCC continuously in horizontal layers not exceeding eighteen (18) inches. Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows placement operations to continue as uninterrupted as possible. Place PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Do not allow the PCC to drop more than five (5) feet

from the end of the discharge chute. Use a metal pipe or channel to deliver PCC at depths greater than five (5) feet. Handle the PCC in a manner that minimizes segregation.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

During cold weather periods, place PCC only when the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature falls below forty (40) degrees Fahrenheit. Do not place PCC on frozen materials.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements. Do not place PCC at night without the Engineer's permission. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

Consolidate the PCC throughout the length of the pad by inserting and withdrawing a vibrator(s) at a minimum of four (4) locations within the pad. Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern.

Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC. Do not drag the vibrator through the PCC. Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

Finish the top of the pad to be approximately one (1) inch above the adjacent ground or structure unless otherwise indicated in the Contract Documents. Finish the top of the pad to be equal with the surrounding sidewalk elevation when constructing a pad within the limits of a sidewalk.

Protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds for a minimum of three (3) days. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer.

Remove forms as soon as practicable after the PCC has hardened without damaging the PCC. Remove any PCC surface irregularities exposed by the removal of the forms by sanding or filling with mortar in a manner acceptable to the Engineer.

Backfill the excavation and restore any areas disturbed by the pad construction. Backfill using lean clay or silty clay materials compacted to ninety-five (95) percent of the maximum density determined in accordance with ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

Dress the top of the PCC pad to provide for proper seating of the controller cabinet base. Heavily coat all areas that contact the PCC foundation on all aluminum bases with an aluminum-filled, resilient sealing compound. Install the controller cabinet in accordance with the manufacturer's recommendations and the Contract Documents.

(D) Traffic Signal Controller Installation.

Install the Type 170 controller in accordance with the manufacturer's recommendations. Terminate all green and yellow one hundred twenty (120) VAC outputs for switch packs numbers 1, 4, 7, and 10 using two thousand (2,000) ohm, twelve (12) watt resistors to AC neutral. Install the filtering surge protector in accordance with the manufacturer's instructions. On the 336, 336S, and 332 cabinets, mount the filtering surge protector outside of the PDA-2.

Mount the surge suppressor on the female terminal connector. Mount the terminal connector inside the cabinet and wire to the Type 170 C2 connector. For 332 master cabinets, mount two (2) surge suppressors and connectors in the cabinet and wire to the Type 170 C20 connector. Connect wires to the pins as illustrated in Table 904.04. Connect all surge suppressor ground connections to the cabinet ground.

Table 904.04
Pin Wiring Diagram

Pin	C2 Connector	C20 Connector
A	Red Wire	White Wire
B	Blue Wire	Green Wire
C	Green Wire	Blue Wire
D		
E	White Wire	Red Wire

Neatly train all wiring installed inside cabinets. Identify all exiting cables. Indicate the destination loop of traffic signal cables and pedestrian push button cables. Indicate the following on all exiting cables:

- Function of vehicle destination loop detector lead in cables.
- Direction of preemption of vehicle preemption cable.
- Function of overhead vehicle detection cables.
- Origination direction of communication cable.

Ensure that identification is permanent.

Provide a minimum of twelve (12) inches of slack for all wire and cable, excluding communication cable, installed in a pole-mounted cabinet after all connections have been made. Provide a minimum of eighteen (18) inches of slack for all wire and cable, excluding communication cable, pulled into a pad-mounted cabinet after all connections have been made. All communications cable shall be a minimum four (4) feet long in the cabinet.

(E) Telephone Line Installation.

Install telephone data and voice lines to those controller cabinets as directed by the Contract Documents. Install telephone lines inside a two (2) inch diameter PVC conduit from the telephone pedestal to the modem inside of the traffic signal controller cabinet. Do not splice the telephone line between the telephone pedestal and the telephone modem inside of the controller cabinet.

904.04 Measurement and Payment.

The Engineer shall measure traffic signal controllers and cabinets for payment as single units supplied, installed, connected, and accepted.

The Engineer shall measure the installation of existing or supplied traffic signal controllers and cabinets for payment as single units installed, connected, and accepted.

The Engineer shall measure auxiliary cabinets for payment as single units supplied, installed, connected, and accepted.

The Engineer shall measure leased telephone line installation for payment as single units installed and accepted.

The Engineer shall measure telephone risers or drops for payment as single units installed and accepted.

The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of the tree or shrub trimming is subsidiary to items for which the Contract provides direct payment. Loading, hauling, construction of all materials, mounting hardware, additional grounding rods, and all miscellaneous hardware is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents. Any costs associated with installing wire/conduit into an existing base/foundation/pad are subsidiary to items for which the Contract provides direct payment. Costs associated with restoration of the surface are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Traffic Signal Controller, Type TC-170 (___ Phase)	Each
Traffic Signal Controller, Type TC-170, 332 Master	Each
Install Traffic Signal Controller	Each
Auxiliary Cabinet	Each
Leased Telephone Line Installation	Each
Telephone Riser Installation	Each
Telephone Drop Installation	Each

THIS PAGE INTENTIONALLY LEFT BLANK

905 – ELECTRICAL CABLE AND DUCT

905.01 Description.

This work includes the furnishing and installing of electrical cable and duct including all materials, equipment, labor, tools, transportation, permits, licenses, and all other miscellaneous items necessary to provide an operable system as required by the Contract Documents.

905.02 Material Requirements.

(A) Conduit and Conduit Fittings.

Conduit and conduit fittings for direct bury applications shall be galvanized rigid steel conforming to UL-6, UL Standard for Safety for Electrical Rigid Metal Conduit – Steel; high-density polyethylene conforming to ASTM F2160, Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD); or rigid polyvinyl chloride conforming to UL-651, UL Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit. Conduit and conduit fittings for boring applications shall be high density polyethylene conforming to ASTM D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter. Furnish in standard lengths with UL label. Rigid steel conduit fittings shall be galvanized steel or galvanized malleable iron. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. PVC conduit fittings and cement shall be compatible with the PVC conduit. Transitions between HDPE and PVC conduits shall conform to the manufacturer's recommendations. Conduit size shall be the minimum trade size permitted for the application and shall have a constant circular cross sectional area. Conduit installed for above ground risers shall be galvanized rigid steel conduit.

(B) Grounding Wires.

Copper grounding wire shall be No. 6 AWG stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire. Copper grounding wire installed in conduit shall be No. 6 AWG green insulated stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire.

(C) Traffic Signal Cables.

Traffic signal cable shall be No. 14 AWG solid wire traffic signal cable with the number of conductors indicated in the Contract Documents. Traffic signal cable shall comply with IMSA Specification 20-1, Specification 20-2, and Specification 20-3. Color code conductors using coloring that penetrates the full thickness of the conductor insulation. Do not color-code using only printed words or numerals on the exterior of the conductor insulation.

(D) Push Button Lead-in Cables.

Push button lead-in cable shall be No. 16 AWG solid wire traffic signal cable with the number of conductors indicated in the Contract Documents. Push button lead-in cable shall comply with IMSA Specification 20-1, Specification 20-2, and Specification 20-3. Color code conductors using coloring that penetrates the full thickness of the conductor insulation. Do not color-code using only printed words or numerals on the exterior of the conductor insulation.

(E) Service Cable: Types SC, SEC and 3/C.

Service Cable for the power source circuits shall be Type THWN copper conductor, gasoline and oil resistant, 600 Volt AWG. Service cable wire shall be black in color and the neutral wire # 6 AWG or smaller shall be white. The cable installation shall conform to the requirements of Article 310 of the National Electric Code. The Service Cable is to run from the power source to the controller.

The Engineer shall size cables from the transformer to the Service Disconnect, referred to as Service Conductors (SC), and cables from the Service Disconnect, referred to as Service-Entrance Conductors (SEC), to meet field conditions.

Cables installed for streetlight luminaries, referred to as 3-conductors (3/C), shall be # 6 AWG wire.

(F) Communication Cables.

Copper-twisted pair communication cable shall be No. 22 AWG solid wire and shall meet the requirements of REA Specification PE-39 and IMSA Specification 60-6. The cable shall contain the number of pairs specified in the Contract Documents. Fiber-optic communication cable shall meet the requirements of ISMA Specification 70 and the specified requirements in the Contract Documents.

Video cable shall meet the requirements of the system manufacturer.

(G) Pull Boxes.

Pull boxes shall be Class 30 cast iron meeting the requirements of ASTM A48, Standard Specification for Gray Iron Castings. Design pull boxes to resist damage from prolonged exposure to sunlight, common ice melting chemicals, or fertilizers. Design the pull box and cover to support AASHTO H-20 Loading. Design the cover to fit tightly and prohibit penetration of flowing water. Emboss the cover with an anti-slip surface pattern when indicated in the Contract Documents or directed by the Engineer.

(H) Cable Pulling Lubricant.

Cable pulling lubricants shall be a commercially available wire pulling compound consisting of soap, talc, mica, or similar materials and designed to have no deleterious effects on the cables being used. Do

not use grease or oil type lubricants typically used on lead sheathed cables.

905.03 Construction Requirements.

(A) General.

Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 905.01 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents. At the time of each submittal, identify in writing any deviations that the shop drawings or samples may have from the requirements of the Contract Documents.

Table 905.01
Materials Information Requirements

Item	Required Information
Conduit and Conduit Fittings	Manufacturer's Model or Catalog Number, Certificate of Compliance
Grounding Wires	Manufacturer's Model or Catalog Number
Traffic Signal Cables	Manufacturer's Model or Catalog Number
Push Button Lead-in Cables	Manufacturer's Model or Catalog Number
Service Cables	Manufacturer's Model or Catalog Number
Communication Cables	Manufacturer's Model or Catalog Number
Luminaire Cables	Manufacturer's Model or Catalog Number
Pull Boxes	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance, Mill Test*, Design Calculation**

* As required by the Engineer
** May substitute catalog number or model number for shop drawings as permitted by the Engineer

Submit proof of the orders and estimated delivery time to the Engineer within fifteen (15) calendar days after receiving approval of the submitted materials information. Identify any materials already in possession. Do not substitute items without written permission from the Engineer. Do not construe Engineer's acceptance of a submittal as relieving the Contractor of the responsibility to comply with the Contract Documents. Obtain all licenses and permits before commencing the work.

A competent worker experienced in the required work shall perform all work under the supervision of a licensed journeyman electrician or lineman. A qualified journeyman electrician or lineman shall directly supervise any work involving the installation of cable, foundations, structural steel, and traffic control equipment. Installations shall comply with all applicable sections of the National Electrical Code, National Electrical Safety Code, Manual on Uniform Traffic Control Devices, all governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Inform the Engineer of the work scheduled each day. Schedule work to minimize the time any signal is inoperable. During this time, provide, place, and maintain temporary traffic control devices in accordance with the City of Omaha's "Manual of Barricading Standards, Specifications, Methods, and Materials". Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Provide the utility company supplying the electrical service adequate notice regarding the scope and nature of the power requirement. Arrange for all necessary electrical services at locations indicated in the Contract Documents. The utility company or Engineer may alter the service location in the field to adapt to certain field requirements. Cooperate with the utility company providing electrical service in locating the service lines and conduit bends.

Trim trees or shrubs using proper tree surgery practices to trim tree branches as necessary to install the poles, mast arms, span wires, or pole. Use an asphaltum-based paint manufactured for tree surgery to treat the cut or scarred branches.

Do not disconnect or damage an operational communication cable while performing work around traffic signal systems without written permission from the Engineer. Reconnect, repair, or establish a temporary connection within eight (8) hours of disconnecting or damaging a communication cable.

Size conduit bends installed in existing foundations to be equivalent to the connecting conduit in the ground. Do not cut or damage the reinforcing steel or anchor bolts in the foundation. Install the conduit a minimum depth of twelve (12) inches below the top of the foundation or thirty (30) inches below the depth of the surrounding ground surface, whichever is greater. Remove a sufficient amount of concrete to place the conduit inside the anchor bolts of the foundation. Position the conduit and place concrete or grout. Finish to match the existing foundation.

Provide and install conductors in the combination mast arm pole and in the luminaire arm, and hook up the luminaire head. Connect the conductors in the pole shaft to the 3/C street lighting cable as required by the Contract Documents. Terminate the 3/C at the service disconnect pedestal.

Replace or restore in kind equal to or exceeding any surface materials disturbed by trenching, excavating, or backfilling operations. Accomplish restoration in accordance with the Contract Documents. Dispose of all excess materials as directed by the Engineer.

Activate and operate the system in normal fashion as soon as possible if the road is open to public travel at the time the installation or any workable segment of the installation is completed. Notify the Engineer a minimum of forty-eight (48) hours before putting the system into operation. Do not put the system into operation without the Engineer present. Secure the services of a person qualified to operate and adjust the system. Test the circuits installed before activating the system.

Neatly route cables to their destinations in cabinets, pole bases, pull boxes, and all other terminations. Submit to the Engineer and follow all manufacturer-recommended values for the allowable bending radii for permanent routing during installation. Drill cable inlet holes in the field as necessary at locations acceptable to the Engineer. Connect cables at the control cabinet using terminal boards provided for this purpose. Equip each stranded wire inserted under a binder screw with a solderless, pressure-type spade connector with a pre-insulated shank. Do not use more than one (1) stranded wire with each spade connector. Do not insert more than three (3) spade connectors under a single binder screw unless otherwise indicated in the Contract Documents or directed by the Engineer. Do not use a spade connector when terminating solid conductor wires. Insert only one (1) solid conductor wire under a binder screw.

After the system is turned on and operating satisfactorily, the City shall assume responsibility for routine maintenance. Maintenance activities by the City do not relieve the Contractor of any responsibility for failures due to workmanship or materials that occur before final acceptance of the project. The Engineer shall decide the responsibility of the Contractor relating to any failure occurring before final acceptance.

Before final acceptance, demonstrate by tests to the Engineer's satisfaction that all electrical installations are in proper condition as required by the Contract Documents. Do not construe operation of the system as acceptance of the system, acceptance of any part of the system, or as a waiver of any contract provisions. All electrical installations are subject to a thirty (30) day trial period before the Engineer may consider the installation for acceptance. The City shall pay for electrical energy consumed by the system during the thirty (30) day operational trial period. Transfer any guarantees or warranties on materials purchased to the City upon acceptance of the work. Purchase materials with transferable guarantees or warranties.

(B) Trench Installation.

Excavate the trench to a width equal to or greater than the outer diameter of the conduit along the route indicated in the Contract Documents. The minimum depth of the conduit shall be thirty (30) inches below finished grade unless otherwise indicated in the Contract Documents or directed by the Engineer. The walls and bottom of the trench shall be firm and without excessive dips or pockets. Remove any soft areas or sharp objects and backfill with suitable materials compacted to the satisfaction of the Engineer.

(C) Trench-less Installation.

Locate jacking pits a minimum of two (2) feet beyond the edge of any pavement. Install conduit by horizontal jacking or boring using approved methods along the route indicated in the Contract Documents. Do not kink or bend sharply the conduit during installation. Accomplish bending in a manner that does not result in any reduction in cross-sectional area.

Replacement of the pavement and back filling the trench shall conform to the applicable Sections of these specifications. No separate payment will be made for the removal or replacement of the pavement or backfilling the trench. In the case of streets and alleys, maintain traffic at all times. In the case of driveways, provide suitable access to the property served by the driveways.

(D) Structures.

Install conduit in or on bridges, retaining walls, tunnels, and similar structures in accordance with the Contract Documents. Supply any special devices or fittings such as hangers, expansion fittings, deflection fittings, junction boxes, drains, grounding materials, and all other fittings required for conduit systems installed in or on structures.

(E) Pull Boxes.

Construct pull boxes at the location shown in the Contract Documents. Obtain the Engineer's permission before installing additional pull boxes to facilitate proper cable installation. Do not construct pull boxes in ditch bottoms, in low areas where water ponding may occur, or where they will be subject to vehicular traffic.

Excavate to the lines and depth specified in the Contract Documents. Install conduit bends as required by the Contract Documents. Plug the ends of the conduit before commencing aggregate placement. Uniformly place and compact an aggregate base without causing segregation or displacing or damaging the underlying subgrade or conduit. Do not place aggregate material if the ambient air temperature is below thirty-five (35) degrees Fahrenheit. Shape the aggregate material to produce a uniform surface meeting the requirements for line and grade as required by the Contract Documents unless otherwise directed by the Engineer. Compact the aggregate base material to a minimum of ninety-five (95) percent of the maximum density as

determined by ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. Maintain the moisture content of the aggregate material in a range that facilitates achieving the required compaction. Construct the aggregate base to a thickness within one-half (½) inch of the thickness indicated in the Contract Documents.

Construct the forms for PCC collar. Level and secure all forms to the satisfaction of the Engineer. Forms shall be wood, metal, or seamless laminated fiber tubes acceptable to the Engineer. Construct forms to be mortar-tight and rigid to prevent distortion due to pressure created by PCC construction. Do not use aluminum forms.

Install pre-formed expansion joint material between the PCC and any abutting structure. Position the pull box frame centered in the PCC collar and level with the top of the forms. Install the pull box lid before commencing PCC placement. Place the PCC continuously in a manner that minimizes disturbance to the forms, pull box frame, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Handle the PCC in a manner that minimizes segregation.

During cold weather periods, place PCC only when the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature falls below forty (40) degrees Fahrenheit. Do not place PCC on frozen materials.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements. Do not place PCC at night without the Engineer's permission. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add water to individual loads on-site before commencing discharge. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

Consolidate the PCC throughout the collar by inserting and withdrawing a vibrator(s) at a minimum of four (4) locations within the collar. Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic

pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC. Do not drag the vibrator through the PCC. Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

Finish the top of the collar to be approximately one-half (½) inch above the adjacent ground unless otherwise indicated in the Contract Documents. Finish the top of the collar to be equal with the surrounding or adjacent sidewalk or pavement elevation when constructing a collar within the limits of a sidewalk. Construct a one-half (½) inch chamfer around all edges exposed to non-paved ground.

Remove forms as soon as practicable after the PCC has hardened without damaging the PCC. Remove any PCC surface irregularities exposed by the removal of the forms by sanding or filling with mortar in a manner acceptable to the Engineer.

When required by the Contract Documents, supply and install a driven ground rod(s) at the base of the pull box as indicated in the Contract Documents in accordance with NEC Article 250.

(F) Backfill.

Backfill trenches, pull boxes, or jacking pits in uniform horizontal layers not exceeding eight (8) inches loose lift thickness. Exercise all necessary caution to avoid damaging the conduit, direct burial cable, or surrounding materials during the backfill process. Construct each layer of the backfill material to the specified density before placing additional layer. Adjust the moisture content as necessary to fulfill moisture requirements. The Engineer reserves the right to alter the thickness of the lifts to meet the specific conditions of the project site. Place successive lifts in a manner that does not significantly alter the moisture content or density of previously completed lifts. When backfilling along a structure, compact embankment materials without applying excessive pressure against the structure. Compact the backfill material uniformly to meet the requirements of Table 905.02. The maximum dry density and optimum moisture shall be determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

Table 905.02
Trench Requirements

Depth	Minimum Compaction	Acceptable Moisture Range
≤ 1 foot (under or within 3 feet of the edge of pavement)	100% of Maximum Dry Density	Optimum Moisture Content ±3%
≤ 1 foot (3 or more feet beyond the edge of pavement)	92% of Maximum Dry Density	Optimum Moisture Content –3%, +5%
Greater than 1 foot	95% of Maximum Dry Density	Optimum Moisture Content ±3%

Demonstrate that the backfill methods comply with the Contract Documents before commencing backfill procedures upon request by the Engineer. Replace any pavement or sidewalk removed during trench installation in accordance with the Contract Documents.

(G) Cable Installation – General.

Neatly route all cables to their final position. Clearly identify all cables using stamped metal or plastic numbered tags. Attach the identification tags to all intermediate points of a cable run within the pull boxes regardless of the presence of a splice. Extend cable outside of transformer bases and pedestal bases a minimum of twenty-four (24) inches before cutting to the proper length. All communications cable in pull boxes, transformer bases, and pedestal bases shall have a minimum of twenty-four (24) inches of slack. All other wire and cable, except ground wire, in pull boxes, transformer bases, and pedestal bases shall have a minimum of eighteen (18) inches of slack.

Splice and joint cables only in pull boxes, pole bases, traffic signal heads, or aerial enclosure. Do not draw a splice or joint inside a conduit. Do not expose a splice or joint to the earth or elements. Perform all splicing in accordance with the cable manufacturer's recommendations, local codes, and good electrical practice. Ground pull boxes when directed by the Engineer. Use high-grade connectors, tape, splicing compound, and other materials acceptable to the Engineer and specifically intended for splicing under the conditions required. Do not use commercially available connector kits for making certain joints without the prior approval of the Engineer. Construct all connections made at terminal boards and at equipment terminals in accordance with the manufacturer's recommendations, local codes, and good electrical practice. Enclose all splices in pull boxes, detector circuits, or other locations susceptible to dampness in a commercially available splicing compound acceptable to the Engineer.

Remove the outer sheathing to expose six (6) to twelve (12) inches of wiring conductor. Strip the wiring conductor ends without damaging the wire and remove any contaminants in a manner acceptable to the Engineer. Do not break the wiring insulation in the process of removing the outer or inner sheathing. Twist the exposed conductors together to form a strong mechanical bond before installing the splice

connector. Train the wire splices upward in cabinets or pole bases to prevent the entrance of moisture into the connector. Waterproof connections or splices in pull boxes using a commercially available splicing compound acceptable to the Engineer. Splice and terminate fiber optic cable in accordance with the manufacturer's recommendations using enclosure and termination devices specifically designed for fiber optic cable.

The Engineer reserves the right to select splices for thorough inspection. For such inspections, sectionalize the splice or connection to expose the various layers of materials and the connector upon request by the Engineer. Upon completion of the inspection, re-splice or connect the wires in accordance with the cable manufacturer's recommendations, local codes, and good electrical practice. If more than five (5) percent of the splices or connections inspected fail to conform to the requirements of the Contract Documents, the Engineer shall reject all similar splices and connections. Repair any splices or connections that do not conform to the Contract Documents at no additional costs to the City.

(H) Cable Installation – Overhead.

Before commencing cable installation, provide the Engineer sufficient notice of installation to allow for coordination with utility facilities. Provide and install all devices or fittings required for the complete overhead cable system. Devices or fittings shall include but not be limited to messenger cables, splices, vertical risers, aerial splice boxes, and all hardware necessary for installation consistent with the current industry standards. Do not allow the cable or messenger to contact with anything that is not a designed part of the system. Notify the Engineer and obtain approval before proceeding if installation of the cable messenger requires such contact.

Install expansion loops at each pole or at the entrance or exit from all equipment. Tape all cable ends to exclude moisture. Do not remove the tape until splicing or attaching terminals. Transitions from overhead to underground installation shall comply with the Contract Documents.

Provide circuit loading as necessary to provide performance that meets or exceeds Bell System Transmission Specifications for Voice Grade Private Line Data Channels (March 1969) for a Type 3002 unconditioned line for all lines.

Upon completion of the installation, perform testing on the equipment and lines to verify continuity and functional performance. Demonstrate line loss and bandwidth for each cable pair.

(I) Cable Installation – Conduit.

Install the conduit along the route indicated in the Contract Documents without damaging the conduit. Reroute the conduit to avoid obstructions or other field conditions as directed by the Engineer. Construct all joints and terminations in accordance with the manufacturer's instructions and the National Electric Code. Joints shall be watertight and mechanically sound. Install bushings at all terminations. Remove sharp edges, corners, or burrs that may damage cables. Cap or plug spare conduits using standard fittings. Demonstrate that the installation methods comply with the Contract Documents before commencing conduit installation upon request by the Engineer.

When required, cut the conduit without altering the cross-section. Ream and smooth all burrs and sharp edges. Use factory made bends and sweeps whenever possible. Field bend the conduit to meet field conditions when approved by the Engineer. Perform field bending using proper tools and equipment specifically designed and intended for this purpose. Perform bending in without creating excessive stresses on the conduit or reducing the cross-sectional area of the conduit. Maximize the radius when bending.

Before installing new cable in existing conduit, remove debris or obstructions from the existing conduit to the satisfaction of the Engineer. Demonstrate that the conduit is dry and free of debris by pulling a swab and/or mandrel through the conduit upon request by the Engineer.

Minimize the number of additional bends, conform to the requirements of the National Electric Code, and install the cables without damage to the cable or duct. Install cable in conduit only after the conduit system is completed.

Install cables using methods that conform to the cable manufacturer's recommendations and do not result in harmful stretching of the cables or injury to the insulation. Furnish written documentation endorsed by the cable manufacturer detailing the methods of attaching pull cable, pulling tension per size and per radius of conduit bend, and the type of lubricant to be used.

Install all cables in a given conduit run simultaneously. Assemble the cables to distribute the pulling tension uniformly to all the cables. Grip insulated cables directly by the conductors or by a basket weave pulling grip applied over the cables, depending on the anticipated maximum pulling tension. Do not use a basket weave grip without obtaining approval from the Engineer before commencing the cable installation. Use pulling eyes for all long or hard pulls. Remove the insulation from the ends of the wires and form a loop using the conductors. Attach the pull wire or rope to the loop. Use a grip over the insulation in addition

to the conductor connection to prevent any slippage of one with respect to the other when directed by the Engineer.

Do not exceed the manufacturer's recommend maximum pulling tension. When required by the Engineer, install a dynamometer in the pull wire during cable installation to monitor pulling tension. Feed the cable(s) into the conduit from the supply reel without making a reverse curve. Draw the pulling wire and cable(s) in a direct line with the conduit. Use sheaves or other suitable devices to reduce any hazards to the cable during installation as necessary. Lubricate the cables to reduce friction and minimize potential damage.

(J) Cable Installation – Direct Burial.
Install the direct burial cable along the route indicated in the Contract Documents. Do not install direct burial cable under a roadway or into a pull box, base, or other structure. Route all cable under a roadway or into a pull box, base, or other structure in conduit installed in accordance with the Contract Documents. Reroute the direct burial cable to avoid obstructions or other field conditions as directed by the Engineer. Unreel the cable parallel and alongside the trench by moving the reel. Before placing the cable in the trench, verify that the installation depth is a minimum of thirty (30) inches below final grade unless otherwise indicated in the Contract Documents or directed by the Engineer. Place the cable in the trench section by section without dragging or stretching. Do not drag, kink, or otherwise damage the cable during this operation.

905.04 Measurement and Payment.

The Engineer shall measure pull boxes for payment as single units constructed and accepted.

The Engineer shall measure the installation of supplied pull boxes for payment as single units installed and accepted.

The Engineer shall measure the conduit for payment as the number of linear feet of conduit installed and accepted. The Engineer shall measure conduit installation from the horizontal center to horizontal center of pull box or foundation disregarding any vertical change or splicing.

The Engineer shall measure the electrical cable or conductors for payment as the number of linear feet of electrical cable or conductors installed and accepted. The Engineer shall measure electrical cable or conductors installation from the horizontal center to horizontal center of pull box or foundation disregarding any vertical change, slacking, or splicing.

The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of the tree or shrub trimming and debris or obstruction removal from

existing conduit is subsidiary to items for which the Contract provides direct payment. Loading, hauling, construction of all materials, mounting hardware, special devices or fittings, additional grounding rods, and all miscellaneous hardware is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents. Any costs associated with installing wire/conduit into an existing base/foundation/pad are subsidiary to items for which the Contract provides direct payment. Costs associated with restoration of the surface are subsidiary to items for which the Contract provides direct payment. Any costs associated with preparing and/or repairing an inspected splice or connection is subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Pull Box, Type ___	Each
Pull Box, Type ___, ___ Lid	Each
Install Pull Box, Type ___	Each
___" PVC Conduit - Trenched	Linear Feet
___" PVC Conduit - Under Roadway	Linear Feet
___" PVC Conduit - Under Sidewalk	Linear Feet
___/C No. 14 AWG Traffic Signal Cable	Linear Feet
___ Pair Communication Cable	Linear Feet
___/C Detector Lead-In Cable	Linear Feet
___/C No. 6 AWG Copper Service Cable,	Linear Feet
___/C No. 16 AWG Pedestrian Push Button Lead-In Cable	Linear Feet
___/C No. 6 Bare Copper Grounding Conductor,	Linear Feet
___/C No. 6 Street Lighting Cable	Linear Feet
Conduit Elbow In Existing Base	Each
Provide And Install Phone Drop	Lump Sum

THIS PAGE INTENTIONALLY LEFT BLANK

906 – PAVEMENT MARKINGS

906.01 Description.

This work includes furnishing and installing pavement markings including all materials, equipment, labor, tools, transportation, permits, licenses, and all other miscellaneous items as required by the Contract Documents.

906.02 Material Requirements.

(A) Pavement Marking Paint.

Lane line paint shall meet the requirements of Table 906.01 and Type N paint as defined by AASHTO M248, Ready-Mixed White and Yellow Traffic Paints. Determine compliance with Table 906.01 using ASTM D2205, Standard Guide for Selection of Tests for Traffic Paints. White paint coloring shall be pure flat white, free of tint.

Table 906.01
Lane Line Paint Requirements

Item	White	Yellow
Acrylic Emulsion Vehicle Resin Solids, %	43 min.	43 min.
pH	9.6 min.	9.6 min.
Twelve (12) mil Wet Thickness Drying Time at Ninety (90) Percent Relative Humidity, minutes	75 max.	75 max.
Twelve (12) mil Wet Thickness Contrast Ration, %	98 min.	96 min.
Daylight Directional Reflectance, %	83 min.	50 min.
Volatile Organic Content, pounds per gallon	1.25 max.	1.25 max.
Track Free Time, minutes	3 max.	3 max.
Settling, Rating	6 or Better	6 or Better
Water Resistant	Yes	Yes
CIE Chromaticity Limits		x = 0.470 to 0.530 y = 0.429 to 0.483

Use one hundred (100) percent acrylic polymer as the vehicle for the paint. Do not use lead, chromate, or other toxic heavy metals in lane line paints. Screen the paint using a No. 40 or finer mesh to remove coarse particles, skins, or other foreign materials. Store paint in containers that will maintain the properties of the paint for a period of one (1) year commencing on the date of acceptance. Provide the manufacturer's recommended storage procedures. Replace any paint that is improperly stored and becomes unacceptable within that one (1) year period.

Store lane line paint in containers constructed to withstand rough handling. Label each container with the following information:

- Manufacturer's name and address
- Shipping point
- Trademark or trade name
- Paint type and color
- Paint formula or manufacturer's guaranteed formula number

- Number of gallons
- Batch date and number

(B) Glass Beads.

Glass beads for use in lane line painting shall conform to the requirements for Type 1 Glass beads as defined by AASHTO M247, Glass Beads Used in Traffic Paints except a minimum of eighty (80) percent shall be true spheres. Treat the beads with a moisture resistant silicone treatment and a silane adherence surface treatment.

Supply the glass beads in fifty (50) pound or two thousand (2,000) pound waterproof and leak-proof containers. Label each container with the following information:

- Manufacturer's name and address
- Trademark or trade name
- Batch and packaging date
- Weight
- Lot Number

Keep the beads dry without caking at all times.

(C) Non-Lane Line Paint.

Use non-lane line paint for crosswalks, stop bars, island noses, hatching, or as directed by the Engineer. Non-lane line paint shall meet the requirements of Type N paint as defined by AASHTO M248, Ready-Mixed White and Yellow Traffic Paints except as modified herein. White paint coloring shall match Federal Standard No. 595a, Color 37886. Non-lane line paint shall not discolor or decrease its light-fastness for a minimum period of two (2) years after installation. Use one hundred (100) percent acrylic polymer as the vehicle for the paint. Do not use lead, chromate, or other toxic heavy metals in lane line paints. Screen the paint using a No. 40 or finer mesh to remove coarse particles, skins, or other foreign materials.

Table 906.02
Non-Lane Line Paint Typical Pigment Formula

Material	White		Yellow	
	Pounds	Gallons	Pounds	Gallons
Emulsion HD-21 (49% NV)	469.8	53.09	469.8	53.09
Tamol 901 (30% NV)	7.2	0.68	7.2	0.68
Surfynol CT-136	2.8	0.32	2.8	0.32
Drew L-493	2.0	0.28	2.0	0.28
Ti-Pure R-900	100.0	2.92	20.0	0.58
Omyacarb-5	760.6	33.69	750.0	33.25
Hansa Yellow (11-2400) (75)	N/A	N/A	16.0	1.35
Hansa Yellow (Y1-805) (65)	N/A	N/A	16.0	1.10

Mix the above until all the pigment is incorporated; then add:

Table 906.03
Non-Lane Line Paint Additive Formula

Material	White		Yellow	
	Pounds	Gallons	Pounds	Gallons
Methanol	30.0	4.50	30.0	4.50
Texanol	23.5	3.00	23.5	3.00
Drew L-493	3.5	0.49	3.5	0.49
Natrosol 250 HR (2% aqueous)	8.6	1.03	11.3	1.36
Preservative (See Note 1)	1408	100	1352.1	100.00

Note 1-The manufacturer shall also add a sufficient quantity of a non-mercurial microbicide can preservative to prevent any growth of microorganisms.

Determine compliance with Table 906.04 using ASTM D2205, Standard Guide for Selection of Tests for Traffic Paints.

Table 906.04
Non-lane line paint Requirements

Item	White	Yellow
Titanium Dioxide ASTM D 476 Type II Rutile 92% min. TiO_2	1 lb/gal min.	0.2lb/gal min.
Minimum Density, Pounds per gallon	14.00	13.45
Dry Opacity, Minimum contrast ratio	0.995	0.880
Pigment, Percent by weight	60.0 to 62.0	56.1 to 58.1
Consistency, Krebbs, Grams	190 to 300	
Equivalent K.U.	80 to 95	
Maximum Lead Content, Percent by weight	0.06	
No-Pick-Up Drying Time, Maximum minutes	12	
Dry-through Drying Time, Maximum minutes	120	
Track-free Field Drying Time, Maximum minutes	2	
pH, Minimum	9.8	
Maximum Volatile Organic Content, Grams per liter	115	
Minimum Closed Cup Flash Point, Fahrenheit	115	

Store non-lane line paint in containers constructed to withstand rough handling and maintain the properties of the paint for a period of one (1) year commencing on the date of acceptance. Provide the manufacturer's recommended storage procedures. Replace any paint that is improperly stored and becomes unacceptable within that one (1) year period. Label each container with the following information:

- Manufacturer's name and address
- Shipping point
- Trademark or trade name
- Paint type and color
- Paint formula or manufacturer's guaranteed formula number
- Number of gallons
- Batch date and number

(D) Preformed Pavement Marking Tape Markings.

Preformed pavement marking tape markings shall be 3M Type 380 or Type 420 Preformed Pavement Marking Tape or pre-approved equal. The manufacturer shall guarantee the adhesion and reflectivity after initial installation for a period of four (4) years for longitudinal

preformed pavement marking tape markings and a period of two (2) years for preformed pavement marking tape symbols.

906.03 Construction Requirements.

(A) General.

Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 906.05 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents. At the time of each submittal, identify in writing any deviations that the shop drawings or samples may have from the requirements of the Contract Documents.

Table 906.05
Materials Information Requirements

Item	Required Information
Lane Line Paint	Manufacturer's Model or Catalog Number, Certificate of Compliance, Notarized Chemical Analysis
Glass Beads	Manufacturer's Model or Catalog Number, Certificate of Compliance
Preformed Pavement Marking Tape Markings	Manufacturer's Model or Catalog Number, Certificate of Compliance

Obtain all licenses and permits before commencing the work. A competent worker, experienced in the required work, shall perform all installations. Installations shall comply with all applicable sections of the Manual on Uniform Traffic Control Devices, all governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Inform the Engineer of the work scheduled each day. Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Schedule work to minimize the time any traffic lane is inoperable. During this time, provide, place, and maintain temporary traffic control devices in accordance with the City of Omaha's "Manual of Barricading Standards, Specifications, Methods, and Materials". Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

After pavement marking installation, the City shall assume responsibility for routine maintenance. Maintenance activities by the City do not relieve the Contractor of any responsibility for failures due to workmanship or materials that occur before final acceptance of the

project. The Engineer shall decide the responsibility of the Contractor relating to any failure occurring before final acceptance.

(B) Pavement Markings Installation – General.

Install pavement markings at the location and true to line according to the Manual of Uniform Traffic Control Devices and the Contract Documents. Remove old markings and place new markings before shifting or adjusting traffic patterns. Notify the Engineer immediately of any conflicting pavement markings. Remove and replace any markings if the center or edge of the marking deviates from the line indicated in the Contract Documents by more than one half (½) inch in fifty (50) feet. Remove pavement markings without altering or damaging the pavement surface or texture. Remove any residue that may interfere with drainage, pollute the environment, or create a traffic hazard. Preserve the color and texture of the adjoining pavement. Do not cover markings with paint or asphalt emulsion.

Maintain all temporary pavement markings during construction in a manner acceptable to the Engineer. In cases of serious or willful disregard for safety of the traveling public or construction workers, the Engineer may re-install pavement markings in proper condition and deduct the cost from Contractor payment. The Engineer reserves the right to suspend the work for failure to provide or maintain pavement markings. Designate a traffic control supervisor to monitor traffic control operations at all times. The traffic control supervisor shall be available to respond to calls at any time. Provide the name of the traffic control supervisor to the Engineer and local police before commencing the work.

(C) Pavement Markings Installation – Paint.

Equipment for installing painted pavement markings shall consist of but not be limited to surface cleaning machine, mechanical marking machine, bead dispensing machine, and any hand equipment necessary to perform the work. The mechanical marking machine shall be an atomizing spray-type machine designed for the application of pavement marking paint and acceptable to the Engineer. The mechanical marking machine shall produce a uniform film thickness at the specified coverage.

Clean the surface to remove all loose or detrimental material. Lay out the markings before commencing installation of painted paint markings. Mix the paint in accordance with the manufacturer's instructions. Apply the marking paint to a dry surface with a surface temperature between fifty (50) and one hundred twenty (120) degrees Fahrenheit and a minimum of five (5) degrees Fahrenheit above the atmospheric dew point. Apply paint with a uniform cross section and clear-cut edges without running, spattering, or over-spray along the lines designated in the Contract Documents. Do not use thinner or other chemicals to alter the paint composition. Apply permanent paint at a

minimum rate of one hundred fifteen (115) square feet per gallon. Apply temporary paint at a minimum rate of two hundred eighty (280) square feet per gallon.

Apply glass beads for all permanent painted pavement markings at a rate of seven (7) pounds per gallon of paint using a bead dispensing machine. Attach the bead-dispensing machine to the marking machine in accordance with the manufacturer's instruction. Cease painting operation if the glass beads do not adhere to the cured paint. The Engineer reserves the right to require a demonstration of the painted pavement marking installation before commencing marking on the project.

Protect all painted markings until the paint has dried. Allow twenty-four (24) hours before applying temporary paint to a new ACC pavement. Allow thirty (30) days before applying additional coats of paint.

(D) Pavement Markings Installation – Marking Tape.

Lay out the markings before commencing installation of preformed pavement marking tape markings. Install preformed pavement marking tape markings in grooved channels or recesses in PCC or existing ACC pavements. Grooving is not required for installations during the construction of ACC pavement.

Groove the line or area to receive preformed pavement marking tape markings. Locate the groove two (2) inches away from a construction joint in the pavement surface. Limit the grooving width to one (1) inch greater than the preformed pavement marking tape marking for line markings. Limit the grooving width to one (1) inch beyond the edge for preformed pavement marking tape symbols. Transition all grooved channels or recesses to match the pavement surface. Accomplish grooving using a machine equipped with stacked diamond cutting heads and a vacuuming system. The bottom of the groove shall have a fine corduroy finish. If a coarse tooth pattern is present, increase the number of blades and decrease the spacers on the cutting head. Grooves shall conform to the requirements of Table 906.06. Accomplish line grooving in one (1) pass of the grooving machine. Clean the grooved surface to remove all loose or detrimental material.

Table 906.06
Groove Requirements

Item	Required Information
Groove width	Tape width + $1 \pm \frac{1}{8}$ inch
Groove depth	50 mils ± 10 mils
Groove length	Tape Length + Grooving Transition

Use methods and self-vacuuming grooving equipment acceptable to the preformed pavement marking tape manufacturer. Grooving equipment shall leave the grooved surface ready for preformed pavement marking

tape installation. Grooves shall be clean and dry before tape application. Apply the preformed pavement marking tape marking using manual or automatic equipment. Place the pavement marking tape in the grooves the same day as constructing the grooves. Use application equipment capable of cutting the preformed pavement marking tape markings to the proper length. Place parallel centerlines simultaneously four (4) inches apart unless otherwise indicated in the Contract Documents. Roll the preformed pavement marking tape marking with a steel drum roller to seat the marking on the underlying surface. The size of the roller shall be sufficient to seat the preformed pavement marking tape material to the satisfaction of the Engineer.

Remove any conflicting pavement markings remaining after preformed pavement marking tape installation.

Preformed pavement marking tape marking installation shall be subject to a one hundred eighty (180) day trial period commencing upon completion of the installation of all preformed pavement marking tape markings. Replace any unacceptable installations at no additional cost to the City. Perform replacements within seven (7) days of receiving notice of unacceptable markings unless unfavorable weather conditions delay replacements. The Engineer shall assess a penalty of one hundred (100) dollars per day for each favorable day past the seven (7) day period.

(E) Pavement Marking Acceptance.

The Engineer shall observe all pavement markings for a period of one hundred eighty (180) days commencing upon the initial completion of all pavement marking installation before final acceptance of all pavement markings. Final acceptance of all marking will include an inspection of the appearance of the markings during daylight and darkness. Maintain or replace, as directed by the Engineer, any marking performing unsatisfactorily due to defective materials and/or workman-ship in manufacture and/or application as determined by the Engineer. At the end of the observation period, the minimum required marking retention for any installed marking shall be ninety five (95) percent.

Final acceptance of the pavement marking will be : (1) 180 days after the initial completion of all work, or (2) upon completion of all corrective work, whichever occurs last. Re-apply or repair, as determined by the Engineer, any unsatisfactory markings at no additional cost to the City of Omaha.

The Engineer shall determine the marking retention percentage as the nominal area of the marking less the area of loss divided by the nominal area expressed as a percentage. The City shall notify the Contractor, in writing, of any marking(s) failing to meet the minimum marking retention requirements within thirty (30) days after completion

of the observation period. When such a claim is made before August 1st, install the replacement material installed during that same construction season in accordance with the Contract Documents. Install replacement material for any claim after August 1st, before June 1st of the following year in accordance with the Contract Documents.

906.04 Measurement and Payment.

Paint and glass beads installed for the City will not be paid for directly but will be paid for by the linear foot of lane lines painted and accepted.

The Engineer shall measure lane line painting for payment by the linear foot of lane line painted and accepted.

The Engineer shall measure non-lane line painting for payment by the linear foot of non-lane line painted and accepted.

The Engineer shall measure lane line preformed pavement marking tape marking for payment by the linear foot of lane line preformed pavement marking tape marking supplied, installed, and accepted.

The Engineer shall measure preformed pavement marking tape markings for payment by the linear foot of preformed pavement marking tape supplied, installed, and accepted.

The Engineer shall measure preformed pavement marking tape symbols for payment as single units supplied, installed, and accepted.

The Engineer shall measure installation of City-furnished preformed pavement marking tape symbols for payment as single units installed and accepted

Removal of temporary markings, conflicting markings, and/or existing markings, as necessary, is subsidiary to items for which the Contract provides direct payment. The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. Loading, hauling, construction of all materials and all miscellaneous items is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for the cost for grooving, furnishing and installing the pavement markings, and furnishing and installing primer; and all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Temporary Painted Pavement Marking – ___	Linear Foot
Permanent Painted Pavement Marking – ___	Linear Foot
___" Preformed Pavement Marking Tape Pavement Marking – ___	Linear Foot
Preformed Pavement Marking Tape Marking Symbol	Each
Install (City Furnished) Traffic Symbol	Each

THIS PAGE INTENTIONALLY LEFT BLANK

907 – BARRICADES AND SIGNAGE

907.01 Description.

This work includes supplying and/or erecting barricades and signage for temporary and permanent traffic control. Erect signs on the roadside or attached to overhead structures at locations indicated in the Contract Documents or as directed by the Engineer. Support signs using one or more metal posts attached to metal sleeves or posts imbedded in the ground, metal street light poles, traffic signal poles, cantilever sign structures, sign brackets, or other supports as required by the Contract Documents. Steel sign brackets attaching to roadway bridges spanning the roadway shall include a sign lighting system as required by the Contract Documents.

907.02 Material Requirements.

(A) Fiber Optic Blank Out Sign.

House fiber optic blank out signs using a black housing thirty (30) inches wide and thirty-six (36) inches high manufactured by National Sign & Signal Company or a pre-approved equal. Attach a black visor to the top and sides of the sign. The minimum depth of the visor shall be seven (7) inches. Supply all necessary mounting hardware for the mounting location indicated in the Contract Documents.

Each pixel point bundle shall have a minimum tip diameter of sixty-eight-thousandths (0.068) inch. The maximum spacing between pixel point bundles shall be one-half (½) inch. Use a minimum of four (4) light sources to illuminate the fiber optic sign message. Cover or house fiber bundles interior to the front sign panel to conceal these bundles when the sign housing is opened for light source replacement. Do not conceal the light sources. Fiber shall be glass. Do not use synthetic fiber. Provide two (2) replacement light sources for each sign installed.

(B) LED Blank Out Sign.

House LED blank out signs using a black housing thirty (30) inches wide and thirty-six (36) inches high manufactured by National Sign & Signal Company or a pre-approved equal. LED blank out signs shall use white LED lighting. Attach a black visor to the top and sides of the sign. The minimum depth of the visor shall be seven (7) inches. Supply all necessary mounting hardware for the mounting location indicated in the Contract Documents.

(C) Sign Lighting Equipment.

Sign lighting equipment luminaire housing shall be weather-tight, have an adequate mounting for sign lighting, and accommodate a one hundred seventy-five (175) watt mercury vapor lamp. The luminaire shall have a maximum foot-candle uniformity ratio of five (5) to one (1) and minimum reading of ten (10) foot-candles with the luminaire mounted as shown in the Contract Documents over an eight (8) foot

wide by six (6) foot high sign. Design the mounting to allow positioning of the luminaire between thirty (30) and sixty (60) inches from the face of the sign.

The ballast for the luminaire shall be a high power factor, regulated output type. House the ballast in a weather-tight enclosure located on the main chord of the truss. Submit a production model luminaire of the type proposed for use on the project to the Engineer for approval before ordering luminaires for the project. Submittal of pre-approved models is not required. The Engineer shall return the submitted luminaire to the Contractor after completing the inspection.

The photoelectric control shall be a cadmium sulfide type providing an operating range of 1 to 3 foot-candles. The units shall operate at a voltage of one hundred twenty (120) volts AC at temperatures of minus twenty (–20) to one hundred twenty (120) degrees Fahrenheit. It shall include a built–in lightning arrestor and be equipped to mount in standard three-prong (3-prong) twist-lock receptacle. It shall be complete with the necessary pole top mounting accessories. Provide secondary relays for switching the 120/240 line voltage to the lighting fixtures. Mount the relays in separate rain-tight housing.

(D) Signs, Barricades, and Advance warning systems.
Signs, barricades, and advance warning systems shall comply with all requirements of the Manual for Uniform Traffic Control Devices for the type required by the Contract Documents. Signs shall be flat, 6061-T6 aluminum.

(E) Temporary Sign Drums.
Drums used for temporary signs shall be approximately three (3) feet high and a minimum of eighteen (18) inches in diameter. Mark the drums using four (4) to eight (8) inch wide white and orange reflective horizontal sheeting. Alternate the reflective sheeting colors. The reflective sheeting shall display the same approximate size, shape, and color in the day or night.

(F) Square Tubular Posts.
Square tubular posts shall be twelve (12) gauge, four (4) pounds per foot, cold-rolled steel conforming to the requirements of ASTM A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process. Use twelve (12) gauge, two and one-half (2½) per foot, cold-rolled steel posts when allowed by the Contract Documents or the Engineer. Punch evenly spaced holes for the full length of the post before rolling. Use a punching process that does not create cracking around the holes. Roll the post to have a square cross section and welded corner conforming to the requirements of the Contract Documents. The weld flash shall allow the placement of a nine-sixty-fourths ($^{9}/_{64}$) inch radius gage in the welded corner. Consecutive size posts shall allow ten (10) feet of

telescoping. Supply posts one and seven eighths ($1\frac{7}{8}$) to two and one eighth ($2\frac{1}{8}$) inches longer than the length indicated in the Contract Documents. Square tubular posts shall meet the requirements of Table 907.01.

Table 907.01
Square Tubular Post Requirements

Allowable Tolerances	Nominal Outside Dimension (inch)			
	1¾" x 1¾"	2" x 2"	2¼" x 2¼"	2½" x 2½"
Outside Measurement All Sides at Corners	± 0.008"	± 0.008"	± 0.010"	± 0.010"
Squareness of Sides	±0.0100"	±0.0120"	±0.0140"	±0.0150"
Side Twist in 3 Feet	0.0620" Max.	0.0620" Max.	0.0620" Max.	0.0750" Max.
Wall Thickness	- 0.008", +0.011"			
Convex or Concavity at the Center of Flat Sides	0.0100" Max.			
Straightness Deviation in Three (3) Feet	0.0625" Max.			
Corner Radius	0.15625" ± 10%			
Hole Size	0.4375" ± 0.015625"			
Hole Spacing	1.0000" ± 0.125" On Center			

(G) Steel U-Posts.

Manufacture steel u-posts from steel conforming to the requirements of ASTM A499, Standard Specification for Steel Bars and Shapes, Carbon Rolled from "T" Rails. Steel u-posts shall have a uniform channeled cross section. The outside dimension of the channel base shall be three (3) to three and one-fourth (3¼) inches wide. Punch three-eighths ($\frac{3}{8}$) inch diameter holes along the bottom of the channel throughout the full length of the sign post. Evenly space the holes one (1) inch on center in the center of the channel bottom. Center the holes along the middle of the channel bottom width. The maximum allowable deviation from the required positioning is one-sixteenth ($\frac{1}{16}$) inch.

(H) Yielding Post Support Structure.

Yielding post supports shall meet the requirements of AASHTO Publication LTS-4, Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals and National Cooperative Highway Research Program 350, Recommended Procedures for Safety Performance Evaluation of Highway Features.

(I) Fasteners and Mounting Hardware.

Sign fasteners shall be rust resistant. Bolts for use on square tubular posts shall be 5/16-18 angle bolts manufactured by Unistrut Corporation or approved equal. All other bolts shall be 5/16-18 zinc plated Whiz-Lock bolts manufactured by Maclean-Fogg Company or approved equal. Fasteners for holding signs to square tubular posts shall be reusable.

Banding shall be stainless steel straps, three-fourths (¾) inch wide, with a minimum thickness of twenty -thousandths (0.020) inch. Banding seals shall be Band-It C 163 or approved equal.

Sign Brackets for use with banding shall be Band-It D0-22 galvanized brackets or approved equal. Cantilever sign brackets for street name signs shall be Vulcon Signs and Stamping, Inc. Model Number VSS-1C or approved equal.

(J) Steel Sign Brackets.
Steel sign brackets to be attached to existing bridges shall be fabricated from structural steel conforming to ASTM A36, Standard Specification for Structural Steel, with a maximum working stress of twenty thousand (20,000) pounds per square inch.

(K) Copper Grounding Wire, Grounding Rods, and Test Stakes.
Copper grounding wire shall be No. 6 AWG stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire. Copper grounding wire installed in conduit shall be No. 6 AWG green insulated stranded copper wire as defined by ASTM B3, Standard Specification for Soft or Annealed Copper Wire.

Grounding rods and test stakes shall comply with IMSA Specification Number 62-1956 excluding length and diameter requirements. Ground rods and test stakes shall have a minimum diameter of five-eighths (⅝) inch. Supply ground rods and test stakes with a ground rod clamp.

(L) Conduit and Conduit Fittings.
Conduit and conduit fittings for direct bury applications shall be galvanized rigid steel conforming to UL-6, UL Standard for Safety for Electrical Rigid Metal Conduit – Steel; high-density polyethylene conforming to ASTM F2160, Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD); or rigid polyvinyl chloride conforming to UL-651, UL Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit. Conduit and conduit fittings for boring applications shall be high density polyethylene conforming to ASTM D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter. Furnish in standard lengths with UL label. Rigid steel conduit fittings shall be galvanized steel or galvanized malleable iron. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. PVC conduit fittings and cement shall be compatible with the PVC conduit. Transitions between HDPE and PVC conduits shall conform to the manufacturer's recommendations. Conduit size shall be the minimum trade size permitted for the application. Conduit installed for above ground risers shall be galvanized rigid steel conduit.

(M) Portland Cement.

Portland cement shall conform to the requirements for Cement Type I or Cement Type II as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3.

(N) Water.

All water used in PCC shall meet the requirements of AASHTO T26, Quality of Water to be used in Concrete. Obtain such water from a source approved by the Engineer.

(O) Aggregate.

Coarse aggregate shall conform to all requirements for Size D57, Class 4S aggregate as defined by ASTM C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of a minimum of seventy-five (75) percent by weight of limestone, quartzite, dolomite, or crushed gravel materials. Fine aggregate shall conform to all requirements for fine aggregate as defined by ASTM C33, Specification for Concrete.

(P) Admixtures.

Admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete; ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete; or ASTM C260, Standard Specification of Air-Entraining Admixtures for Concrete. Dosages shall be as directed by the manufacturer.

Calcium chloride shall meet the requirements of ASTM D98, Specifications for Calcium Chloride. The maximum amount of calcium chloride added shall not exceed two (2) percent by weight of the total amount of cement in the mixture. Do not use calcium chloride without prior written approval by the Engineer. Add calcium chloride on the project site in a manner acceptable to the Engineer. Mix calcium chloride flake in a minimal amount of water before adding to the PCC. Mix the calcium chloride solution with the concrete for a minimum of thirty (30) revolutions before commencing placement of the PCC.

Do not use any admixtures that retard the initial set of the PCC without prior approval by the Engineer. Add water-reducing admixtures at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

(Q) PCC Mix Proportioning.

Proportion PCC mixtures to meet the requirements of Table 907.02.

Table 907.02
PCC Properties

Mix Type	L6
Portland Cement Content, lbs. per cubic yard	564
Coarse Aggregate, % of Total Aggregate	30±3
Fine Aggregate, % of Total Aggregate	70±3
Maximum Water Cement Ratio	0.45
Minimum 28-Day Compressive Strength, psi	3500
Air Content, %	6.5±1.0
Slump, inches	4-inch Max.
Concrete Temperature during placement, °F	70±25

Referenced Test Procedures.

- ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173, Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C143, Test Method for Slump of Hydraulic Cement Concrete
- ASTM C1064, Test Method for Temperature of Freshly Mixed Portland Cement Concrete

(R) Reinforcing Steel.

Reinforcing steel shall be deformed steel bars conforming to the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, or ASTM A996, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement. Do not use Grade 50 or Grade 60 rail steel bars for tie bars that are bent or straightened during construction. For construction requiring bent bars, use Grade 40 tie bars meeting the requirements of ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

(S) Curing Materials.

Curing materials shall conform to one of the following specifications:

- Liquid membrane-forming compounds for curing PCC shall conform to the requirements for Type 1, 1-D, or 2, Class B as defined by ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
- Polyethylene film for curing PCC shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete

(T) Pre-molded Joint Filler.
Pre-molded joint filler for expansion joints shall conform to the requirements of ASTM D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types). Neatly punch holes to admit the dowels where indicated in the Contract Documents. The diameter of the holes shall not exceed one-half (½) inch greater than the bar diameter. When more than one piece is required for a joint, securely fasten the abutting ends by stapling or other positive fastening means satisfactory to the Engineer.

907.03 Construction Requirements.

(A) General.
Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 907.03 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents. At the time of each submittal, identify in writing any deviations that the shop drawings or samples may have from the requirements of the Contract Documents.

Table 907.03
Materials Information Requirements

Item	Required Information
Luminaire Housing	Manufacturer's Model or Catalog Number, Working Drawing*
Luminaire	Manufacturer's Model or Catalog Number, Working Drawing*
Photoelectric Control	Manufacturer's Model or Catalog Number, Working Drawing*
Signs	Manufacturer's Model or Catalog Number
Barricades	Manufacturer's Model or Catalog Number
Advance Warning Systems	Manufacturer's Model or Catalog Number, Working Drawing*
Wood Posts	Manufacturer's Model or Catalog Number, Manufacturer's Data Identifying Species, Size, Class, and Treatment
Steel U-Posts	Manufacturer's Model or Catalog Number, Certificate of Compliance
Mounting Hardware	Manufacturer's Model or Catalog Number
Metal Poles	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance, Mill Test**, Design Calculation**
Mast Arms	Manufacturer's Model or Catalog Number, Certificate of Compliance, Mill Test**, Design Calculation**
Anchor Bolts	Manufacturer's Model or Catalog Number, Certificate of Compliance
Wire and Cable	Manufacturer's Model or Catalog Number, Certificate of Compliance
Conduit	Manufacturer's Model or Catalog Number

* As required by the Engineer
** May substitute catalog number or model number for shop drawing as permitted by the Engineer

Obtain all licenses and permits before commencing the work. A competent worker experienced in the required work shall perform all work involving traffic control equipment. Wire all circuits as required by the Contract Documents, clear of faults, grounds, and open circuits. Installations shall comply with all applicable sections of the National Electrical Code, National Electrical Safety Code, Manual on Uniform Traffic Control Devices, all governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Provide the utility company supplying the electrical service adequate notice regarding the scope and nature of the power requirement. Arrange for all necessary electrical services at locations indicated in the Contract Documents. The utility company or Engineer may alter the service location in the field to adapt to certain field requirements. Cooperate with the utility company providing electrical service in locating the service lines and conduit bends.

Trim trees or shrubs using proper tree surgery practices to trim tree branches as necessary to install the poles, mast arms, span wires, or pole. Use an asphaltum-based paint manufactured for tree surgery to treat the cut or scarred branches.

Size conduit bends installed in existing foundations to be equivalent to the connecting conduit in the ground. Do not cut or damage the reinforcing steel or anchor bolts in the foundation. Install the conduit a minimum depth of twelve (12) inches below the top of the foundation or thirty (30) inches below the depth of the surrounding ground surface, whichever is greater. Remove a sufficient amount of concrete to place the conduit inside the anchor bolts of the foundation. Position the conduit and place concrete or grout. Finish to match the existing foundation.

Replace or restore in kind equal to or exceeding any surface materials disturbed by trenching, excavating, or backfilling operations. Accomplish restoration in accordance with the Contract Documents. Dispose of all excess materials as directed by the Engineer.

Before final acceptance, demonstrate by tests to the Engineer's satisfaction that all electrical installations are in proper condition as required by the Contract Documents. Do not construe operation of the system as acceptance of the system, acceptance of any part of the system, or as a waiver of any contract provisions. All electrical installations are subject to a thirty (30) day trial period before the Engineer may consider the installation for acceptance. The City shall pay for electrical energy consumed by the system during the thirty (30) day operational trial period. Transfer any guarantees or warranties on

materials purchased to the City upon acceptance of the work. Purchase materials with transferable guarantees or warranties.

After the system is turned on and operating satisfactorily, the City shall assume responsibility for routine maintenance. Maintenance activities by the City do not relieve the Contractor of any responsibility for failures due to workmanship or materials that occur before final acceptance of the project. The Engineer shall decide the responsibility of the Contractor relating to any failure occurring before final acceptance.

(B) Sign Construction.

Degrease aluminum by totally immersing the metal in a saturated vapor of trichloroethylene or perchloroethylene or in a tank containing alkaline solutions. Control and titrate the alkaline solutions in accordance with the manufacturer's recommendations. Rinse alkaline soak metals with running water.

Acid etch the metal using a six (6) to eight (8) percent phosphoric acid or other acid etching solution acceptable to the Engineer at one hundred (100) degrees Fahrenheit. Thoroughly rinse the metal using cold running water, then hot running water if desired. Dry the metal using a forced hot air dryer. Do not allow the metal to contact grease, oils, or other contaminants before applying the reflective sheeting.

The sign face shall comply with the Manual of Uniform Traffic Control Devices.

Apply reflective sheeting or paint using mechanical equipment and methods acceptable to the sheeting or paint manufacturer and the Engineer. Match multiple piece signs before applying the reflective sheeting or paint to ensure uniformity. Reverse alternate, successive width sections of sheeting or panels consecutively to ensure corresponding edges lie adjacent on the finished sign. Signs with mismatched background color of adjacent sheets or panels are not acceptable.

Age the reflective sheeting for forty-eight (48) hours at seventy-five (75) degrees Fahrenheit. Continue aging if the reflective sheeting strips from the panel using a stiff putty knife.

Apply the legend and border using a direct-screened or reverse-screened process. The direct-screened process shall consist of the screen process method. Use a process color material and obtain a dry film thickness in accordance with the reflective sheeting or paint manufacturer's recommendations. The reverse-screen process shall consist of processing an opaque or transparent color over the sign face. Use an opaque or transparent process color material and obtain a dry

film thickness in accordance with the reflective sheeting or paint manufacturer's recommendations.

(C) Temporary Sign Post Installation.
Attach a two (2) foot u-post vertically to the inside of the drum and bolt to a u-post with the required sign(s) on the outside of the drum. Position the drum and sign and fill with a minimum of one hundred fifty (150) pounds of aggregate.

(D) Permanent Sign Post Installation.
Install posts in ground using a drop hammer or similar equipment acceptable to the Engineer. Drive posts a minimum of four (4) feet below the surface of the surrounding ground. Install posts in PCC using a V-Loc Socket System Anchor or approved equal. Grout the posts in the PCC base. Crown the surface of the grout to shed water away from the post.

Locate the posts to provide a minimum clearance of nine (9) inches from the nearest vertical edge of the sign to the near edge of the roadway. Drive posts a minimum of three (3) feet into the ground. Driven posts shall be perpendicular to the longitudinal slope of the roadway.

(E) Cantilever Sign Structure Installation.
Cantilever sign structure foundations shall comply with the Contract Documents. Provide a structural engineering design on all foundations where the mast arm length exceeds sixty-one (61) feet. A Structural Engineer currently licensed to practice in the State of Nebraska shall seal the design.

Dig or bore holes to the lines and depth specified in the Contract Documents for the construction of the metal pole foundation. Foundations shall be round. Construct forms for the upper two (2) feet of the foundation. The minimum dimension for the mounting surface shall be two and one-half (2½) inches greater than the pole base or transformer base on all sides. The excavation shall be dry and free of any loose materials before placing PCC. Level and secure all forms to the satisfaction of the Engineer before commencing PCC placement.

Forms shall be wood, metal, or seamless laminated fiber tubes acceptable to the Engineer. Construct forms to be mortar-tight and rigid to prevent distortion due to pressure created by PCC construction. Do not use aluminum forms.

Supply and install a driven ground rod(s) at the base of each pole as indicated in the Contract Documents before commencing PCC placement. The ground rod shall extend a minimum of eight (8) inches above the finished foundation and a minimum of eight (8) feet beneath

the bottom of the foundation. Install the ground rod in accordance with NEC Article 250.

Install and secure all reinforcing steel and conduit in a manner acceptable to the Engineer. Center the bolt circle in the middle of the foundation and set the anchor bolts plumb in the foundation at a projection distance in accordance with the pole manufacturer's instructions. Conduit bends shall be ninety (90) degrees and shall exit the foundation a minimum of thirty (30) inches below the level of the surrounding ground. Plug the ends of the conduit before commencing PCC placement. Install pre-formed expansion joint material between the pole foundation and any abutting PCC structure.

Provide all equipment, labor, and tools necessary to perform the work to the satisfaction of the Engineer. The National Ready Mixed Concrete Association shall certify that the production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or

embedded items, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

Place the PCC continuously in horizontal layers not exceeding eighteen (18) inches. Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows placement operations to continue as uninterrupted as possible. Place PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Do not allow the PCC to drop more than five (5) feet from the end of the discharge chute. Use a metal pipe or channel to deliver PCC at depths greater than five (5) feet. Handle the PCC in a manner that minimizes segregation.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

During cold weather periods, place PCC only when the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature falls below forty (40) degrees Fahrenheit. Do not place PCC on frozen materials.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements. Do not place PCC at night without the Engineer's permission. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add

water to individual loads on-site before commencing discharge. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

Consolidate the PCC throughout the length of the foundation by inserting and withdrawing a vibrator(s) at a minimum of four (4) locations within the foundation. Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC. Do not drag the vibrator through the PCC. Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

Finish the top of the foundation to be approximately one (1) inch above the adjacent ground or structure unless otherwise indicated in the Contract Documents. Finish the top of the foundation to be equal with the surrounding sidewalk elevation when constructing a foundation within the limits of a sidewalk.

Protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds for a minimum of three (3) days. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer.

Remove forms as soon as practicable after the PCC has hardened without damaging the PCC. Remove any PCC surface irregularities exposed by the removal of the forms by sanding or filling with mortar in a manner acceptable to the Engineer.

Backfill the excavation and restore any areas disturbed by the foundation construction. Backfill the foundation with lean clay or silty clay materials compacted to ninety-five (95) percent of the maximum density determined in accordance with ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

Dress the top of the PCC foundation to provide for proper seating of the pole base. Heavily coat all areas that contact the PCC foundation on all aluminum bases with an aluminum-filled, resilient sealing compound. Install the poles in accordance with the manufacturer's recommendations and the Contract Documents.

Position the pole with the hand hole facing away from vehicular traffic wherever possible. Install leveling nuts as directed by the pole manufacturer regardless of the need for adjustment. Install a one (1) inch inside diameter rubber grommet below the mast arm installation location. Plumb pedestal poles using shims supplied by the pole base manufacturer. After plumbing the metal pole, fill any void between the pole base and the pole foundation with grout. Install a one-half (½) inch conduit in the grout for drainage as directed by the Engineer.

Install a No. 6 AWG stranded green insulated copper conductor attached to the ground rod using an approved clamp and connected to the grounding lug on the pole shaft. Grounding shall be in accordance with the NEC, local ordinances, all applicable codes, and the requirements of the local utility company supplying electrical power. The Engineer shall resolve any discrepancies. Do not connect any grounding connections to a breakaway device.

The maximum measurable resistance between the ground rod and a test stake driven two (2) feet into the ground adjacent to the PCC pole foundation shall not exceed twenty-five (25) ohms. If the resistance exceeds twenty-five (25) ohms, install additional ground rods greater than six (6) feet apart and connected using a No. 4 AWG bare copper wire. The number of additional ground rods shall be as needed to produce a measurable resistance of less than twenty-five (25) ohms.

Install mast arms in accordance with the manufacturer's instructions such that the loaded arm has a minimum clearance of seventeen (17) feet above the crown of the roadway. The minimum rise of the end of the loaded arm shall be zero (0) degrees. Install a one (1) inch inside diameter rubber grommet on the bottom of the mast arm near the connection to the pole. Rake the pole back more than the calculated deflection, load the pole, and plumb the pole by adjusting the leveling nuts.

(F) Sign Installation.

Place traffic control devices at their specified location before starting construction. Maintain traffic devices during mobile operations. In cases of serious or willful disregard for safety of the traveling public or construction workers, the Engineer may place traffic control devices in proper condition and deduct the cost from Contractor payment. The Engineer will suspend work when it is determined that safe traffic control provisions are not being provided or maintained. Designate a traffic control supervisor to monitor traffic control operations at all

times. Ensure that the supervisor is available to respond to calls at any time. Provide the name of the traffic control supervisor at the preconstruction conference and to local police.

Maintain temporary traffic control devices in accordance with the City of Omaha's "Manual of Barricading Standards, Specifications, Methods, and Materials." Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

Mount signs at the height and location in accordance with Contract Documents and the Manual of Uniform Traffic Control Devices. The minimum mounting height shall be seven (7) feet. Define the mounting height as the vertical distance from the bottom of the sign to the near edge of the pavement. Use a minimum mounting height of six (6) feet for secondary signs mounted below another sign. Orient all signs, except parking control signs, at a ninety (90) degree angle with the roadway edge. Orient parking control signs with arrows at a forty-five (45) degree angle with the roadway edge. The Engineer shall resolve any conflicts.

Erect signs vertical and oriented to maximize effectiveness in day and night conditions. Avoid orienting signs to avoid the possibility of specular reflections. Maintain a minimum clearance of seventeen (17) feet above the crown of the roadway for overhead installations. Handle and erect signs in a manner that prevents damage to the signs. Replace any sign damaged before final acceptance at no additional cost to the City.

907.04 Measurement and Payment.

The Engineer shall measure the installation of City-provided overhead signs on a lump sum basis.

The Engineer shall measure the installation of posts and City-provided traffic signs on a lump sum basis.

The Engineer shall measure the installation of posts and Contractor-provided traffic signs on a lump sum basis.

The Engineer shall measure a changeable message sign on a lump sum basis.

The Engineer shall measure the furnishing and operation of a flashing arrow panel on a per calendar day basis.

The Engineer shall measure furnishing, erecting, and maintaining temporary barricades and warning signs on a lump sum per calendar day basis. Individual signs will not be measured separately.

The cost of additional ground rods is incidental to other items in the Contract for which direct payment is made.

The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of the tree or shrub trimming is subsidiary to items for which the Contract provides direct payment. Loading, hauling, construction of all materials, mounting hardware, additional grounding rods, and all miscellaneous hardware is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents. Any costs associated with installing wire/conduit into an existing base/foundation/pad are subsidiary to items for which the Contract provides direct payment. Costs associated with restoration of the surface are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for furnishing, fabricating and attaching the sign or sign assemblies to the sign post(s) or structure(s); including the furnishing of the aluminum sign blanks, furnishing and applying the finish material to the sign face, process material and screens for processing and processing the legend and border on the sign face and furnishing all sign posts, anchor posts, yielding structural support, bolts, nuts, mounting hardware for attaching sign or sign assembly to sign post(s) or structure(s) and for all equipment, tools, labor, materials, and incidentals necessary to complete the work.

Description	**Unit**
Install Overhead Signs, Signs Provided By City	Lump Sum
Install Traffic Signs & Posts, Signs Provided By City	Lump Sum
Install Traffic Signs & Posts, Signs Provided By Contractor	Lump Sum
Changeable Message Sign	Lump Sum
Furnishing & Operating Flashing Arrow Panel	Day
Barricades And Warning Signs	Day

908 – SERVICE DISCONNECTS

908.01 Description.

This work includes furnishing and installing a traffic signal system service disconnect pedestal for permanent construction or a service disconnect switch for temporary construction including all materials, equipment, labor, tools, transportation, permits, licenses, and all other miscellaneous items necessary to provide an operable system as required by the Contract Documents.

908.02 Material Requirements.

(A) Service Enclosure.

The service enclosure shall be Tesco Class 26-100-UM-A or equal and shall meet the requirements of UL 508, Industrial Control Equipment. Fabricate the exterior of the service enclosure using one-eighth (⅛) inch aluminum. Fabricate the interior of the service enclosure using fourteen (14) gauge, cold-rolled steel. Paint the interior of the service enclosure white. The interior dimensions of the service enclosure shall be twelve (12) inches wide, forty-three (43) inches high, and seven and one-half (7½) inches deep. The service enclosure shall have continuously welded seams, a full-length deadfront with stainless steel hinge, and a pull section with a removable step.

The service enclosure shall have a fully framed, side-hinged, swaged outer door, flush fitted with top drip lip and closed cell neoprene flange-compressed gaskets. The service enclosure shall have a hinged deadfront with a one-fourth (¼) turn latch and knurled knobs. Hinge the deadfront door on the same side as the exterior door. The deadfront door shall open a minimum of one hundred (100) degrees. Mount a removable backpan on four (4) welded one-fourth (¼) inch studs. The service enclosure shall be completely pre-wired in the factory. Provide a generator transfer switch when indicated in the Contract Documents. Bolt-on or plug-in circuit breakers are not acceptable.

The service enclosure manufacturer shall furnish independent laboratory certification that the metal preparation, the finish, and the overall product comply with the Contract Documents. The Engineer reserves the right to require and witness compliance testing.

(B) Service Disconnect Switch Enclosure.

Service disconnect switch enclosures for temporary applications shall meet the requirements of a NEMA Type 3R enclosure, service rated, and sixty (60) amp fused.

(C) Wiring Schematics.

Produce wiring schematics using drafting software. Include all external equipment and connections in accordance with NEMA IIB. Enclose

as-built factory drawings in clear plastic. Store drawings inside the outer door using welded hooks.

(D) Service Conductors.
Service conductors shall meet the requirements of Section 230 of the National Electrical Code.

(E) Wood Post.
Wood posts shall conform to the requirements of AASHTO Publication LTS-4, Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

908.03 Construction Requirements.

(A) General.
Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 908.01 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents. At the time of each submittal, identify in writing any deviations that the shop drawings or samples may have from the requirements of the Contract Documents.

Table 908.01
Materials Information Requirements

Item	Required Information
Service Enclosure	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance
Service Disconnect Enclosure	Manufacturer's Model or Catalog Number, Certificate of Compliance, Mill Test**, Design Calculation**
Service Conductors	Manufacturer's Model or Catalog Number, Certificate of Compliance
Wood Poles	Manufacturer's Model or Catalog Number, Certificate of Compliance

* As required by the Engineer
** May substitute catalog number or model number for shop drawing as permitted by the Engineer

A competent worker experienced in the required work shall perform all work under the supervision of a licensed journeyman electrician or lineman. A qualified journeyman electrician or lineman shall directly supervise any work involving the installation of cable, foundations, structural steel, and traffic control equipment. Wire all circuits as required by the Contract Documents, clear of faults, grounds, and open circuits. Connect the service neutral conductor and all interconnected equipment grounding conductors solidly to a driven ground rod at the traffic signal service disconnect pedestal. Installations shall comply with all applicable sections of the National Electrical Code, National Electrical Safety Code, Manual on Uniform Traffic Control Devices, all

governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Inform the Engineer of the work scheduled each day. Schedule work to minimize the time any signal is inoperable. During this time, provide, place, and maintain temporary traffic control devices in accordance with the City of Omaha's "Manual of Barricading Standards, Specifications, Methods, and Materials". Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Provide the utility company supplying the electrical service adequate notice regarding the scope and nature of the power requirement. Arrange for all necessary electrical services at locations indicated in the Contract Documents. The utility company or Engineer may alter the service location in the field to adapt to certain field requirements. Cooperate with the utility company providing electrical service in locating the service lines and conduit bends.

Identify the location of permanent disconnect and obtain approval from the Engineer before commencing construction of the foundation.

Trim trees or shrubs using proper tree surgery practices to trim tree branches as necessary to install the poles, mast arms, span wires, or pole. Use an asphaltum-based paint manufactured for tree surgery to treat the cut or scarred branches.

Do not disconnect or damage an operational communication cable while performing work around traffic signal systems without written permission from the Engineer. Reconnect, repair, or establish a temporary connection within eight (8) hours of disconnecting or damaging a communication cable.

Size conduit bends installed in existing foundations to be equivalent to the connecting conduit in the ground. Do not cut or damage the reinforcing steel or anchor bolts in the foundation. Install the conduit a minimum depth of twelve (12) inches below the top of the foundation or thirty (30) inches below the depth of the surrounding ground surface, whichever is greater. Remove a sufficient amount of concrete to place the conduit inside the anchor bolts of the foundation. Position the conduit and place concrete or grout. Finish to match the existing foundation.

Replace or restore in kind equal to or exceeding any surface materials disturbed by trenching, excavating, or backfilling operations. Accomplish restoration in accordance with the Contract Documents. Dispose of all excess materials as directed by the Engineer.

Activate and operate the system in normal fashion as soon as possible if the road is open to public travel at the time the installation or any workable segment of the installation is completed. Notify the Engineer a minimum of forty-eight (48) hours before putting the system into operation. Do not put the system into operation without the Engineer present. Secure the services of a person qualified to operate and adjust the system. Test the circuits installed before activating the system.

Before final acceptance, demonstrate by tests to the Engineer's satisfaction that all electrical installations are in proper condition as required by the Contract Documents. Do not construe operation of the system as acceptance of the system, acceptance of any part of the system, or as a waiver of any contract provisions. All electrical installations are subject to a thirty (30) day trial period before the Engineer may consider the installation for acceptance. The City shall pay for electrical energy consumed by the system during the thirty (30) day operational trial period. Transfer any guarantees or warranties on materials purchased to the City upon acceptance of the work. Purchase materials with transferable guarantees or warranties.

After the system is turned on and operating satisfactorily, the City shall assume responsibility for routine maintenance. Maintenance activities by the City do not relieve the Contractor of any responsibility for failures due to workmanship or materials that occur before final acceptance of the project. The Engineer shall decide the responsibility of the Contractor relating to any failure occurring before final acceptance.

(B) Permanent Service Disconnect Switch Installation.

Locate the service disconnect switch box within the line of sight of the controller cabinet and within one hundred (100) feet or less of the controller cabinet unless otherwise directed by the Engineer or the Contract Documents.

Dig or bore holes to the lines and depth specified in the Contract Documents for the construction of the pedestal foundation. The foundation shall be round or square. The excavation shall be dry and free of any loose materials before placing PCC. Level and secure all forms to the satisfaction of the Engineer before commencing PCC placement.

Forms shall be wood, metal, or seamless laminated fiber tubes acceptable to the Engineer. Construct forms to be mortar-tight and

rigid to prevent distortion due to pressure created by PCC construction. Do not use aluminum forms.

Install and secure all reinforcing steel and conduit in a manner acceptable to the Engineer. Center the bolt circle in the middle of the foundation and set the anchor bolts plumb in the foundation at a projection distance in accordance with the pole manufacturer's instructions. Conduit bends shall be ninety (90) degrees and shall exit the foundation a minimum of thirty (30) inches below the level of the surrounding ground. Plug the ends of the conduit before commencing PCC placement. Install pre-formed expansion joint material between the pole foundation and any abutting PCC structure.

Provide all equipment, labor, and tools necessary to perform the work to the satisfaction of the Engineer. The National Ready Mixed Concrete Association shall certify that the production facilities and delivery fleet meet the requirements of Section 3, Certification of Ready Mixed Concrete Production Facilities, of the National Ready Mixed Concrete Association Quality Control Manual. Maintain the production facility to comply with the requirements of such certification. The Engineer reserves the right to verify that the production facility complies with the certification requirements. Only central mixing production facilities are acceptable.

Accomplish concrete placement using buckets, hoppers, buggies, chutes, drop pipes, conveyor belts, and/or other necessary placement equipment acceptable to the Engineer. Use clean equipment having proper capacity and in proper working order. The maximum allowable free-fall drop for PCC material shall be five (5) feet. When desirable, place PCC using clean pumping equipment or conveyors in proper working condition.

Pumping equipment shall use uniformly sized pipes and hoses having a minimum diameter equal to three (3) times the maximum aggregate size. Use conveyor belts that are concave and sized to accommodate the required weigh of PCC. Pumping and conveyor equipment shall permit PCC placement at any location within the placement area without significant interruption or delay. Conveyor equipment shall be capable of stopping, holding, and restarting when fully loaded. Locate the pump or conveyor equipment as near as practical to the final PCC destination. Configure pipes and conveyors to minimize bends or turns.

Before commencing PCC placement, verify that all reinforcement and embedded items are properly prepared and free of mud, oils, or other coatings that may affect bonding unless otherwise indicated in the Contract Documents. Remove any loose rust or mill scale present on reinforcing steel. Place reinforcement in the proper position in a manner acceptable to the Engineer. Secure all reinforcement or

embedded items, positioned before PCC placement, using supports and ties. Do not walk or stand on positioned reinforcement or embedded items during PCC placement.

Place the PCC continuously in horizontal layers not exceeding eighteen (18) inches. Provide concrete in a manner that provides constant, continuous supply of the PCC mixture. Deliver PCC at a uniform rate compatible with the available labor and equipment that allows placement operations to continue as uninterrupted as possible. Place PCC in a manner that minimizes disturbance to the forms, reinforcement, and underlying materials. Place a sufficient quantity to allow for proper consolidation and strike-off to the required elevation and thickness. Do not allow the PCC to drop more than five (5) feet from the end of the discharge chute. Use a metal pipe or channel to deliver PCC at depths greater than five (5) feet. Handle the PCC in a manner that minimizes segregation.

Position equipment to allow an unrestricted vertical drop to the point of placement or into the conveyor vehicle. Accomplish PCC placement using the lowest practical slump that allows for proper consolidation. Deposit fresh PCC at or near its final position in the placement. Maintain the slope of chutes and drop chutes to facilitate continuous, controlled, and non-segregated PCC supply. Use chutes or drop chutes having a minimum diameter of nine (9) inches. Place PCC in a manner that minimizes lateral movement of the deposited material.

Prime pumping equipment and pre-wet conveyors before commencing placement. Discard materials used to prime pumping equipment before commencing placement operations. Operate pumping and conveyor equipment to supply PCC as continuous as possible. Maintain the slope of conveyors to prevent loss or segregation of the PCC material during conveyance. PCC shall conform to the requirements of the Contract Documents after pumping or conveying. Minimize PCC exposure to ambient conditions during conveying.

During cold weather periods, place PCC only when the ambient air temperature is thirty-five (35) degrees Fahrenheit and rising. Cease placement operations when the ambient air temperature falls below forty (40) degrees Fahrenheit. Do not place PCC on frozen materials.

Use sufficient labor and equipment to permit proper placement, consolidation, and finishing of the PCC. Provide sufficient lighting acceptable to the Engineer for night or low-light placements. Do not place PCC at night without the Engineer's permission. The Contractor is responsible for any damage to the PCC due to weather conditions or other factors.

Add water or admixtures to PCC to increase workability or correct deviations from the requirements of the Contract Documents. Add

water to individual loads on-site before commencing discharge. Add admixtures at the plant. Do not add any admixtures on-site without the approval of the Engineer. Do not exceed the maximum allowable water-cement ratio. If the amount of mixing water added at the plant is not available, do not add any water on-site. Mix PCC for a minimum of one (1) minute after adding water on-site at a mixer speed of thirty (30) revolutions per minute or greater. Do not add any water after commencing PCC discharge.

Consolidate the PCC throughout the length of the foundation by inserting and withdrawing a vibrator(s) at a minimum of four (4) locations within the foundation. Do not use vibration to move PCC laterally. Insert and withdraw tube vibrators vertically at close intervals in a systematic pattern. Allow running vibrators to sink into the PCC under their own weight. Do not force vibrators into semi-hardened PCC. Do not drag the vibrator through the PCC. Vibrators shall be internal tube vibrators acceptable to the Engineer. Vibrators shall operate at the manufacturer's recommended frequency and be capable of consolidating the full depth and width of the PCC without causing segregation. Keep a tachometer for measuring vibratory frequency available on the jobsite at all times.

Finish the top of the foundation to be approximately one (1) inch above the adjacent ground or structure unless otherwise indicated in the Contract Documents. Finish the top of the foundation to be equal with the surrounding sidewalk elevation when constructing a foundation within the limits of a sidewalk.

Protect the exposed, finished PCC surface from high or low temperature extremes, low humidity, and drying winds for a minimum of three (3) days. Use protection measures that inhibit moisture loss and maintain the PCC temperature at or above fifty (50) degrees Fahrenheit for a minimum of three (3) days unless otherwise directed by Contract Documents or the Engineer. Apply liquid membrane-forming curing compounds at the concentration and application rate recommended by the manufacturer.

Remove forms as soon as practicable after the PCC has hardened without damaging the PCC. Remove any PCC surface irregularities exposed by the removal of the forms by sanding or filling with mortar in a manner acceptable to the Engineer.

Backfill the excavation and restore any areas disturbed by the foundation construction. Backfill the foundation with lean clay or silty clay materials compacted to ninety-five (95) percent of the maximum density determined in accordance with ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

The wiring will be to NEMA IIB standards showing external connections and external equipment. All bussing shall be UL approved copper THHN cable bussing fully rated. Identify the function of all circuit breakers, switches, and other components using laminated engraved plastic nameplates with minimum one-fourth (¼) inch letters fastened with a minimum of two (2) No. 4-40 stainless steel machine screws.

(C) Temporary Service Disconnect Switch Installation.

When required by the Contract Documents, construct wood posts and mountings in a manner acceptable to the Engineer. Dig or bore holes to the lines and depth specified in the Contract Documents for the construction of the wood pole foundation and anchors. Holes shall be round. Minimize the diameter of all holes. The installed post shall support the temporary disconnect in the proper position and to resist swaying or displacement.

Attach the service disconnect switch enclosure to one of the following:

- The wood pole supporting the controller cabinet.
- A wood power pole near the controller cabinet.
- A wood sign post having a minimum dimension of four (4) inches by four (4) inches. Do not use this post for supporting any signs.

Locate the service disconnect switch box within the line of sight of the controller cabinet and within one hundred (100) feet or less of the controller cabinet unless otherwise directed by the Engineer or the Contract Documents.

908.04 Measurement and Payment.

The Engineer shall measure service disconnect pedestals for payment as single units constructed and accepted.

The Engineer shall measure service disconnect pedestals with transfer switches for payment as single units constructed and accepted.

The Engineer shall measure service disconnect switches for payment as single units constructed and accepted.

The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of the tree or shrub trimming is subsidiary to items for which the Contract provides direct payment. Loading, hauling, construction of all materials, mounting hardware, additional grounding rods, and all miscellaneous hardware is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents. Any costs associated with installing wire/conduit into an existing base/foundation/pad are subsidiary to items for which the Contract provides direct payment.

Any cost associated with compliance testing is subsidiary to items for which the Contract provides direct payment. Costs associated with restoration of the surface are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Service Disconnect Pedestal	Each
Service Disconnect Pedestal with Transfer Switch	Each
Service Disconnect Switch	Each

THIS PAGE INTENTIONALLY LEFT BLANK

909 – VEHICLE DETECTORS

909.01 Description.

This work includes furnishing and installing non-video vehicle detection systems including all materials, equipment, labor, tools, transportation, permits, licenses, and all other miscellaneous items necessary to provide an operable system as required by the Contract Documents.

909.02 Material Requirements.

(A) Vehicle Detector Amplifiers – Model 222.
Vehicle detector amplifiers Model 222 shall be compatible with the Type 170 Traffic Control System and shall meet all requirements of the latest version of the Traffic Signal Equipment Specifications published by the State of California Business, Transportation, and Housing Agency.

(B) Vehicle Detectors – Magnetic.
Magnetic vehicle detectors shall be compatible with the Type 170 Traffic Control System and shall meet all requirements of the latest version of the Traffic Signal Equipment Specifications published by the State of California Business, Transportation, and Housing Agency.

(C) Magnetic Vehicle Detector Amplifiers – Model 232.
Magnetic vehicle detector amplifiers Model 232 shall be compatible with the Type 170 Traffic Control System and shall meet all requirements of the latest version of the Traffic Signal Equipment Specifications published by the State of California Business, Transportation, and Housing Agency.

(D) Radar/Microwave Detectors.
Radar/Microwave detectors shall be Microwave Sensors, Inc. Type TC-20 Microwave Sensors or approved equal.

(E) Loop Detector Wire.
Loop detector wire shall be No. 14 AWG Type XHHW, cross-linked polyethylene insulated complying with IMSA 51-3.

(F) Detector Lead-in Cable.
Detector lead-in cable shall be No. 14 AWG stranded, pre-twisted, shielded, waterproof cable complying with IMSA Specification 50-2. Four (4) conductor lead-in cable for magnetometers shall be waterproof instrumentation cable complying with the magnetometer manufacturer's recommendations and approved by the Engineer.

(G) Sealant.
Loop detector sealant shall be Minnesota Mining and Manufacturing Company (3M) Loop Detector Sealant 5000 or approved equal.

(H) Conduit and Conduit Fittings.

Conduit and conduit fittings for direct bury applications shall be galvanized rigid steel conforming to UL-6, UL Standard for Safety for Electrical Rigid Metal Conduit – Steel; high-density polyethylene conforming to ASTM F2160, Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD); or rigid polyvinyl chloride conforming to UL-651, UL Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit. Conduit and conduit fittings for boring applications shall be high density polyethylene conforming to ASTM D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter. Furnish in standard lengths with UL label. Rigid steel conduit fittings shall be galvanized steel or galvanized malleable iron. Galvanizing shall comply with ASTM C123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. PVC conduit fittings and cement shall be compatible with the PVC conduit. Transitions between HDPE and PVC conduits shall conform to the manufacturer's recommendations. Conduit size shall be the minimum trade size permitted for the application. Conduit installed for above ground risers shall be galvanized rigid steel conduit.

909.03 Construction Requirements.

(A) General.

Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 909.01 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents. At the time of each submittal, identify in writing any deviations that the shop drawings or samples may have from the requirements of the Contract Documents.

Table 909.01
Materials Information Requirements

Item	Required Information
Vehicle Detector Amplifier	Manufacturer's Model or Catalog Number
Magnetic Vehicle Detector	Manufacturer's Model or Catalog Number
Magnetic Vehicle Detector Amplifier	Manufacturer's Model or Catalog Number
Radar/Microwave Detectors	Manufacturer's Model or Catalog Number
Loop Detector Wire	Manufacturer's Model or Catalog Number
Detector Lead-in Cable	Manufacturer's Model or Catalog Number
Loop Detector Sealant	Manufacturer's Model or Catalog Number

A competent worker experienced in the required work shall perform all work under the supervision of a licensed journeyman electrician or lineman. A qualified journeyman electrician or lineman shall directly supervise any work involving the installation of cable and traffic control equipment. Wire all circuits as required by the Contract Documents, clear of faults, grounds, and open circuits. Connect the service neutral conductor and all interconnected equipment grounding conductors solidly to a driven ground rod at the traffic signal service disconnect pedestal. Installations shall comply with all applicable sections of the National Electrical Code, National Electrical Safety Code, Manual on Uniform Traffic Control Devices, all governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Inform the Engineer of the work scheduled each day. Schedule work to minimize the time any signal is inoperable. During this time, provide, place, and maintain temporary traffic control devices in accordance with the City of Omaha's "Manual of Barricading Standards, Specifications, Methods, and Materials". Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Provide the utility company supplying the electrical service adequate notice regarding the scope and nature of the power requirement. Arrange for all necessary electrical services at locations indicated in the Contract Documents. The utility company or Engineer may alter the service location in the field to adapt to certain field requirements. Cooperate with the utility company providing electrical service in locating the service lines and conduit bends.

Do not disconnect or damage an operational communication cable while performing work around traffic signal systems without written permission from the Engineer. Reconnect, repair, or establish a temporary connection within eight (8) hours of disconnecting or damaging a communication cable.

Size conduit bends installed in existing foundations to be equivalent to the connecting conduit in the ground. Do not cut or damage the reinforcing steel or anchor bolts in the foundation. Install the conduit a minimum depth of twelve (12) inches below the top of the foundation or thirty (30) inches below the depth of the surrounding ground surface, whichever is greater. Remove a sufficient amount of concrete to place the conduit inside the anchor bolts of the foundation. Position the conduit and place concrete or grout. Finish to match the existing foundation.

Replace or restore in kind equal to or exceeding any surface materials disturbed by trenching, excavating, or backfilling operations. Accomplish restoration in accordance with the Contract Documents. Dispose of all excess materials as directed by the Engineer.

Activate and operate the system in normal fashion as soon as possible if the road is open to public travel at the time the installation or any workable segment of the installation is completed. Notify the Engineer a minimum of forty-eight (48) hours before putting the system into operation. Do not put the system into operation without the Engineer present. Secure the services of a person qualified to operate and adjust the system. Test the circuits installed before activating the system.

Before final acceptance, demonstrate by tests to the Engineer's satisfaction that all electrical installations are in proper condition as required by the Contract Documents. Do not construe operation of the system as acceptance of the system, acceptance of any part of the system, or as a waiver of any contract provisions. All electrical installations are subject to a thirty (30) day trial period before the Engineer may consider the installation for acceptance. The City shall pay for electrical energy consumed by the system during the thirty (30) day operational trial period. Transfer any guarantees or warranties on materials purchased to the City upon acceptance of the work. Purchase materials with transferable guarantees or warranties.

After the system is turned on and operating satisfactorily, the City shall assume responsibility for routine maintenance. Maintenance activities by the City do not relieve the Contractor of any responsibility for failures due to workmanship or materials that occur before final acceptance of the project. The Engineer shall decide the responsibility of the Contractor relating to any failure occurring before final acceptance.

(B) Loop Detector Installation.

Install vehicle detector loops at the locations indicated in the Contract Documents and in accordance with the manufacturer's instructions. The Engineer shall resolve any discrepancies. If the existing pavement is in such condition that proper operation cannot be guaranteed for a period of two years, obtain the Engineer's approval before placing the loop.

Install loops in existing pavement by saw cutting a one-fourth (¼) inch slot in the pavement along the path of the loop. Remove all loose material from the slot using an air compressor. Drill a hole to route the wiring through the curb and gutter to the outside edge of the pavement. Insert the loops into the sawed slot without damaging the wires. Tamp the wire into the slot using a blunt tool. Do not use sharp instruments such as screwdrivers, etc. Exercise caution around corners and sharp bends to avoid damaging the insulation or introducing undue stresses on the wire. Route detector loop wiring through a one-half (½) inch non-metallic flexible tubing at locations where the wiring crosses a roadway expansion joint or crack. Do not route more than three (3) detector loop wires in the same slot. Seal saw cuts and holes from installation of vehicle detectors. Install loops the same day as constructing the saw cuts. Do not open area to traffic after beginning saw cutting until completion of the loop installation.

Install a one half (½) inch diameter schedule 40 polyvinyl chloride conduit for each loop detector from the hole in the curb to the pull box or signal base. Install a three-fourths (¾) inch diameter schedule 40 polyvinyl chloride conduit whenever routing multiple loops through the same hole in the pavement. Do not install more than three (3) loop detector wires in a three-fourths (¾) inch diameter conduit. Splice the loop wire to the loop lead-in cable at a pull box or pole base. Do not install any splices outside of a pull box or pole base.

Install all loops in new pavement by casting them in place. Securely stake the loops on the surface of the underlying subgrade or base course. Use care to prevent damage to the loop during the paving operation. For installations in PCC pavement, position loops before commencing PCC placement. Coat the detector loops with a bond breaking membrane that prevents the PCC from adhering to the conduit. Saw cutting loops into the surface of any new PCC pavement is not acceptable.

For installations in conjunction with ACP overlays or surfacing not more than two (2) inches in depth, the Contractor may saw cut a slot into the underlying pavement surface and position the loops twenty-four (24) hours before placing the surface. Cover the wires with a minimum of one-half (½) inch thick ACP placed by hand and lightly compacted before construction the surface lift. Obtain written permission from the Engineer before installing loops in this manner.

909.04 Measurement and Payment.

The Engineer shall measure vehicle loop detectors as a single unit constructed and accepted.

The Engineer shall measure vehicle loop detector repair as a single unit constructed and accepted.

The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of the tree or shrub trimming is subsidiary to items for which the Contract provides direct payment. Loading, hauling, construction of all materials, mounting hardware, additional grounding rods, and all miscellaneous hardware is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents. Any costs associated with installing wire/conduit into an existing base/foundation/pad are subsidiary to items for which the Contract provides direct payment. Costs associated with restoration of the surface are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Vehicle Detector, ___' X ___' with ___ Turns Of Wire	Each
Vehicle Detector, Type TD-___, ___'x___' with ___ Turns Of Wire	Each
Repair Loop Detector	Each
2 Channel Loop Detector Amplifier	Each

910 – MODULAR VIDEO VEHICLE DETECTION SYSTEM

910.01 Description.

This work includes furnishing and installing single camera, rack-mounted, modular video vehicle detection systems including all materials, equipment, labor, tools, transportation, permits, licenses, and all other miscellaneous items necessary to provide an operable system as set forth in the plans, the special provisions, and these specifications, complete, in place, tested and in operating condition.

910.02 Material Requirements.

(A) General.

The modular video vehicle detection system shall currently be in production. The system shall have a minimum of six (6) months of successful operation at a similar location at the time of the bid opening. Submit a list of users complete with agency name, address, telephone number, and contact person with the bid. Failure to submit the list may result in the rejection of the proposal.

The video detection system shall provide flexible detection zone placement anywhere and at any orientation within the combined field or view of the image sensors. Preferred presence detector configurations shall be lines placed across lanes of traffic or lines placed in-line with lanes of traffic. A single detector line shall be able to replace one or more conventional detector loops connected in series. Design the system to allow overlapping of the detection zones. Detection zones shall have the capability of implementing logical functions including AND, OR, NAND, N of M, and delay/extend timing.

Overall, performance of the video detection system shall be comparable to inductive loop vehicle detectors. The video detection system shall reliably detect vehicle presence when the image sensor is mounted thirty (30) feet or higher above the roadway, when the image sensor is adjacent to the desired coverage area, and when the length of detection area or field of view is not greater than ten (10) times the mounting height of the image sensor.

Using standard image sensing optics without obstructions, the system shall have a minimum vehicle detection accuracy of ninety-eight (98) percent under normal operating conditions. In adverse weather conditions such as shadows, fog, rain, or snow, the minimum vehicle detection accuracy shall be ninety-six (96) percent. Detection accuracy is dependent upon site geometry, camera placement, camera quality, and detection zone location; these accuracy levels do not include

allowances for obstruction or poor video due to camera location or quality.

Using standard image sensing optics without obstructions, the system shall have a maximum vehicle count error of four (4) percent under normal conditions. In adverse weather conditions such as shadows, fog, rain, or snow, the maximum vehicle count error shall be seven (7) percent. Establish the count error over the entire roadway and compile over time intervals containing a minimum of one hundred (100) vehicles.

(B) Video Camera.

The video camera used for traffic detection shall meet the requirements of the video detection processor supplier. The video detection processor supplier shall certify that the camera will ensure proper video detection system operation. Power the camera using 120 VAC 60 hertz. Power consumption shall be less than forty (40) watts under all conditions.

The camera shall produce a useable video image of the bodies of vehicles under all roadway lighting conditions. The minimum range of scene luminance over which the camera shall produce a useable video image shall be five-tenths (0.5) to ten thousand (10,000) lux. The camera shall use a charge coupled device sensing element and shall output monochrome video with resolution of not less than three hundred fifty (350) lines vertical and three hundred eighty (380) lines horizontal.

The camera shall include automatic electronic shutter control based upon average scene luminance. The camera shall include a variable focal length lens with variable focus and zoom adjustable to suit the site geometry without opening up the camera housing. The camera electronics shall include automatic gain control to produce a satisfactory image at night. Configure the camera video signal output in RS170 format. Isolate the video signal from the camera enclosure and power cabling.

House the camera in an environmentally sealed enclosure equipped with a sun shield preventing sunlight from directly entering the lens. Equip the camera enclosure with separate weather-tight power and video cable connections at the rear of the enclosure. Connections shall allow diagnostic testing and viewing of video at the camera without removing the camera from the mast arm or pole. Do not connect the video and power with the same connector. Design the sunshield to divert water from flowing in the field of view of the camera. The camera enclosure with sunshield shall be less than six (6) inches in diameter, less than fourteen (14) inches long, and weigh less than six (6) pounds when the camera and lens are mounted inside the enclosure. The camera enclosure shall include a thermostatically controlled heater

to assure proper operation of the lens iris at low temperature and prevent moisture condensation on the optical faceplate of the enclosure. When mounted outdoors in the enclosure, the camera shall operate satisfactorily in a temperature range from minus thirty four (–34) to sixty (60) degrees Celsius and a humidity range from zero (0) to one hundred (100) percent relative humidity.

(C) Video Detection Processor.

The video detection processor shall process video output from one source in RS170 format, shall be digitized, and shall analyze the video output in real time. Power the video detection processor by twenty-four (24) volts direct current. Video detection processor power consumption shall not exceed four hundred fifty (450) milliamps.

The system shall include software that detects vehicles in multiple lanes using only the video image. A single detection zone shall be capable of replacing multiple detector loops. Detection zones may be separate or together to indicate vehicle presence on a single phase of traffic movement. The video detection processor shall detect the presence of vehicles in up to twenty-four (24) detection zones per camera. The video detection processor shall detect vehicles in real time as they travel across each detector zone. Size a detection zone to suit the site and the desired vehicle detection region. It shall be possible to activate a detection zone pattern for a camera from video detection processor memory and have that detection zone pattern displayed within one (1) second of activation. The video detection processor memory shall store up to three (3) detection zone patterns. Configure the video detection processor memory to prevent memory loss during power outages.

The front of the video detection processor shall display detection indications for each real time detection channel output when the system is operational. The front of the video detection processor shall include one (1) BNC real time video output and one (1) BNC video input connection suitable for RS170 video inputs. The video input shall include a switch selectable impedance termination of seventy-five (75) ohms or higher that allows routing of the camera video to other devices and input to the video detection processor for vehicle detection.

Design the video detection processor to program detector zones using a menu displayed on a video monitor and a pointing device connected to the video detection processor. The menu shall facilitate placement of the detection zones using a pointing device and a graphical interface to draw the detection zones on the video image from each video camera. Design the graphical interface into the video detection processor. The video detection processor shall store up to three different detector zone patterns. The video detection processor shall switch to any one of the three different detector patterns within one (1) second of the user request using menu selection with the pointing device.

The video detection processor shall provide dynamic zone reconfiguration to enable normal detector operation of existing zones except those added or modified during the setup process. The video detection processor shall output a constant call on any detection channel corresponding to a zone undergoing modification. A symbol shall flash on the screen whenever detecting a vehicle crossing the detection zone.

The video detection processor shall have an RS232 port for serial communications with a remote computer. This port shall be a "D" subminiature connector on the front of the video detection processor. The video detection processor shall utilize flash memory technology to enable the loading of modified or enhanced software through the RS232 port without modifying the video detection processor hardware. The video detection processor shall send or accept detector patterns from an external computer through the RS232 port. The video detection processor shall not require a separate computer to program detection zones. The video detection processor shall provide up eight (8) channels of vehicle presence detection through a standard detector rack edge connector and a minimum of one (1) extension modules. The video detection processor shall include a detector output pin compatible with standard detector mounting racks.

Design the video detection processor to mount in a standard detector rack without adapters. Do not require rewiring of the detector rack. Use the edge connector to obtain power and provide contact closure outputs. The video detection processor shall operate satisfactorily in a temperature range from minus thirty-four (-34) to sixty (60) degrees Celsius and a humidity range from zero (0) to ninety-five (95) percent relative humidity, non-condensing.

(D) Extension Module.

The extension module shall conform to the video detection processor manufacturer recommendations and shall output contact closures in accordance with user selectable channel assignments. Power the extension module by twenty-four (24) volts direct current. The extension module power consumption shall not exceed one hundred (100) milliamps. The extension module shall include a detector output pin compatible with standard detector mounting racks.

Design the extension module to mount in a standard detector rack, using the edge connector to obtain power and provide contact closure outputs. Do not require adapters for mounting the video detection processor in a standard detector rack. Do not require rewiring of the detector rack. The extension module shall operate satisfactorily in a temperature range from minus thirty-four (-34) to sixty (60) degrees Celsius and a humidity range from zero (0) to ninety-five (95) percent relative humidity, non-condensing.

(E) Video Signal Transmission Cable.

Video signal transmission cable shall be seventy-five (75) ohm RG-59/U Type, No. 20 AWG bare copper center conductor coaxial video cable suitable for installation in conduit or overhead using appropriate span wire. The video signal transmission cable shall have a polyethylene core, tinned copper double braid ninety-eight (98) percent shield, and be one hundred (100) percent sweep tested. Install BNC plug connectors on both ends of the video signal transmission cable. The BNC connector and crimping tool shall meet the manufacturer's recommendations. Install the BNC connectors in accordance with the manufacturer's instructions.

(F) Power Cabling.

Power cabling shall be No. 16 AWG three (3) conductor cable complying with all applicable NEC and local electrical codes.

(G) Miscellaneous Hardware.

Supply all necessary cables, brackets, and hardware conforming to the manufacturer's recommendations.

(H) Warranty, Maintenance, and Support.

Provide all product documentation. Product documentation must be written in the English language. The supplier shall provide a minimum two (2) year guarantee on the video detection system beginning on the date of acceptance and approval for payment by the City. During this two (2) year period, the supplier shall provide the City continuous hardware and software support including any updates of the machine vision processor or system software at no additional cost. The supplier shall provide technical support, via telephone, within four (4) hours of a request by the City. Factory-certified personnel or installers shall provide such support. The supplier shall negotiate a separate agreement with the City for continued technical support and upgrades following the expiration of the guarantee period.

The supplier shall maintain a program for technical support updates following expiration of the warranty period. Coordinate this program with the City of Omaha in the form of a separate agreement for continuing support.

910.03 Construction Requirements.

(A) General.

Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 910.01 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents. At the time of each submittal, identify in writing any deviations that the

shop drawings or samples may have from the requirements of the Contract Documents.

Table 910.01
Materials Information Requirements

Item	Required Information
Modular Video Vehicle Detection System	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance,
Extension Module	Manufacturer's Model or Catalog Number, Certificate of Compliance
Video Signal Transmission Cable	Manufacturer's Model or Catalog Number

* As required by the Engineer

Do not construe Engineer's acceptance of a submittal as relieving the Contractor of the responsibility to comply with the Contract Documents. The City shall reimburse the Contractor for all other items upon completion and acceptance of the work. Obtain all training, licenses, and permits before commencing the work.

Wire all circuits as required by the Contract Documents, clear of faults, grounds, and open circuits. Connect the service neutral conductor and all interconnected equipment grounding conductors solidly to a driven ground rod at the traffic signal service disconnect pedestal. Installations shall comply with all applicable sections of the National Electrical Code, National Electrical Safety Code, Manual on Uniform Traffic Control Devices, all governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Inform the Engineer of the work scheduled each day. Schedule work to minimize the time any signal is inoperable. During this time, provide, place, and maintain temporary traffic control devices in accordance with the City of Omaha’s "Manual of Barricading Standards, Specifications, Methods, and Materials". Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Provide the utility company supplying the electrical service adequate notice regarding the scope and nature of the power requirement. Arrange for all necessary electrical services at locations indicated in the Contract Documents. The utility company or Engineer may alter the service location in the field to adapt to certain field requirements. Cooperate with the utility company providing electrical service in locating the service lines and conduit bends.

Trim trees or shrubs using proper tree surgery practices to trim tree branches as necessary to install the poles, mast arms, span wires, or pole. Use an asphaltum-based paint manufactured for tree surgery to treat the cut or scarred branches.

Do not disconnect or damage an operational communication cable while performing work around traffic signal systems without written permission from the Engineer. Reconnect, repair, or establish a temporary connection within eight (8) hours of disconnecting or damaging a communication cable.

Size conduit bends installed in existing foundations to be equivalent to the connecting conduit in the ground. Do not cut or damage the reinforcing steel or anchor bolts in the foundation. Install the conduit a minimum depth of twelve (12) inches below the top of the foundation or thirty (30) inches below the depth of the surrounding ground surface, whichever is greater. Remove a sufficient amount of concrete to place the conduit inside the anchor bolts of the foundation. Position the conduit and place concrete or grout. Finish to match the existing foundation.

Replace or restore in kind equal to or exceeding any surface materials disturbed by trenching, excavating, or backfilling operations. Accomplish restoration in accordance with the Contract Documents. Dispose of all excess materials as directed by the Engineer.

Activate and operate the system in normal fashion as soon as possible if the road is open to public travel at the time the installation or any workable segment of the installation is completed. Notify the Engineer a minimum of forty-eight (48) hours before putting the system into operation. Do not put the system into operation without the Engineer present. Secure the services of a person qualified to operate and adjust the system. Test the circuits installed before activating the system.

Before final acceptance, demonstrate by tests to the Engineer's satisfaction that all installations are in proper condition as required by the Contract Documents. Do not construe operation of the system as acceptance of the system, acceptance of any part of the system, or as a waiver of any contract provisions. All electrical installations are subject to a thirty (30) day trial period before the Engineer may consider the installation for acceptance. The City shall pay for electrical energy consumed by the system during the thirty (30) day operational trial period. Transfer any guarantees or warranties on materials purchased to the City upon acceptance of the work. Purchase materials with transferable guarantees or warranties.

After the system is turned on and operating satisfactorily, the City shall assume responsibility for routine maintenance. Maintenance activities by the City do not relieve the Contractor of any responsibility for

failures due to workmanship or materials that occur before final acceptance of the project. The Engineer shall decide the responsibility of the Contractor relating to any failure occurring before final acceptance.

Notify the Engineer one (1) week before changing any approach lanes using video detection during construction to allow for reprogramming of the video detection system.

(B) System Installation.

Before the video cameras are installed, a factory certified representative from the supplier shall review the plans and determine if the placements of the video cameras shown on the plans are suitable. If the placement of any of the video cameras is determined to be not suitable, the supplier's representative shall recommend suitable placement(s) of the video camera(s). Re-install any cameras placed without the supplier review that are not effective due to the placement at no additional cost to the City. A factory certified representative from the supplier shall supervise installation and testing of the system. Install the system in accordance with the manufacturer's instructions.

Unless otherwise indicated in the Contract Documents, install the camera thirty-three (33) feet above the roadway and over the traveled way on which vehicles are to be detected. The camera shall view approaching vehicles at a distance not to exceed three hundred fifty (350) feet for reliable detection. Install the detector at a distance not more than ten (10) times the mounting height of the camera.

Connect the extension module to the video detection processor using a ten (10) wire cable with modular connectors.

(C) System Training.

Provide installation and training support using factory-authorized representatives.

910.04 Measurement and Payment.

The Engineer shall measure modular video vehicle detection systems for payment as single units installed and accepted. The contract price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of the tree or shrub trimming is subsidiary to items for which the Contract provides direct payment. Loading, hauling, construction of all materials, mounting hardware, additional grounding rods, and all miscellaneous hardware is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents. Any costs

associated with installing wire/conduit into an existing base/foundation/pad are subsidiary to items for which the Contract provides direct payment. The cost of the supplier review is subsidiary to items for which the Contract provides direct payment. Costs associated with restoration of the surface are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Modular Video Vehicle Detection System	Each

THIS PAGE INTENTIONALLY LEFT BLANK

911 – PREEMPTION CONTROL SYSTEM

911.01 Description.

This includes furnishing and installing preemption control systems including all materials, equipment, labor, tools, transportation, permits, licenses, and all other miscellaneous items necessary to provide an operable system as required by the Contract Documents.

911.02 Material Requirements.

(A) Preemption Control System.
Preemption control systems shall be the Opticom Priority Control System developed by the 3M Company. No alternatives will be accepted.

(B) Detector Cable.
Detector cable shall be 3M Detector Cable, Model Number 138.

911.03 Construction Requirements.

(A) General.
Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 911.01 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents. At the time of each submittal, identify in writing any deviations that the shop drawings or samples may have from the requirements of the Contract Documents.

Table 911.01
Materials Information Requirements

Item	Required Information
Preemption Control System	Manufacturer's Model or Catalog Number, Working Drawing*
Detector Cable	Manufacturer's Model or Catalog Number

* As required by the Engineer

Do not construe Engineer's acceptance of a submittal as relieving the Contractor of the responsibility to comply with the Contract Documents. The City shall reimburse the Contractor for all other items upon completion and acceptance of the work. Obtain all training, licenses, and permits before commencing the work.

Wire all circuits as required by the Contract Documents, clear of faults, grounds, and open circuits. Connect the service neutral conductor and all interconnected equipment grounding conductors solidly to a driven

ground rod at the traffic signal service disconnect pedestal. Installations shall comply with all applicable sections of the National Electrical Code, National Electrical Safety Code, Manual on Uniform Traffic Control Devices, all governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Inform the Engineer of the work scheduled each day. Schedule work to minimize the time any signal is inoperable. During this time, provide, place, and maintain temporary traffic control devices in accordance with the City of Omaha's "Manual of Barricading Standards, Specifications, Methods, and Materials". Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Provide the utility company supplying the electrical service adequate notice regarding the scope and nature of the power requirement. Arrange for all necessary electrical services at locations indicated in the Contract Documents. The utility company or Engineer may alter the service location in the field to adapt to certain field requirements. Cooperate with the utility company providing electrical service in locating the service lines and conduit bends.

Trim trees or shrubs using proper tree surgery practices to trim tree branches as necessary to install the poles, mast arms, span wires, or pole. Use an asphaltum-based paint manufactured for tree surgery to treat the cut or scarred branches.

Do not disconnect or damage an operational communication cable while performing work around traffic signal systems without written permission from the Engineer. Reconnect, repair, or establish a temporary connection within eight (8) hours of disconnecting or damaging a communication cable.

Size conduit bends installed in existing foundations to be equivalent to the connecting conduit in the ground. Do not cut or damage the reinforcing steel or anchor bolts in the foundation. Install the conduit a minimum depth of twelve (12) inches below the top of the foundation or thirty (30) inches below the depth of the surrounding ground surface, whichever is greater. Remove a sufficient amount of concrete to place the conduit inside the anchor bolts of the foundation. Position the conduit and place concrete or grout. Finish to match the existing foundation.

Replace or restore in kind equal to or exceeding any surface materials disturbed by trenching, excavating, or backfilling operations. Accomplish restoration in accordance with the Contract Documents. Dispose of all excess materials as directed by the Engineer.

Activate and operate the system in normal fashion as soon as possible if the road is open to public travel at the time the installation or any workable segment of the installation is completed. Notify the Engineer a minimum of forty-eight (48) hours before putting the system into operation. Do not put the system into operation without the Engineer present. Secure the services of a person qualified to operate and adjust the system. Test the circuits installed before activating the system.

Before final acceptance, demonstrate by tests to the Engineer's satisfaction that all installations are in proper condition as required by the Contract Documents. Do not construe operation of the system as acceptance of the system, acceptance of any part of the system, or as a waiver of any contract provisions. All electrical installations are subject to a thirty (30) day trial period before the Engineer may consider the installation for acceptance. The City shall pay for electrical energy consumed by the system during the thirty (30) day operational trial period. Transfer any guarantees or warranties on materials purchased to the City upon acceptance of the work. Purchase materials with transferable guarantees or warranties.

After the system is turned on and operating satisfactorily, the City shall assume responsibility for routine maintenance. Maintenance activities by the City do not relieve the Contractor of any responsibility for failures due to workmanship or materials that occur before final acceptance of the project. The Engineer shall decide the responsibility of the Contractor relating to any failure occurring before final acceptance.

Notify the Engineer one (1) week before changing any approach lanes using video detection during construction to allow for reprogramming of the video detection system.

(B) System Installation.

Install the system in accordance with the manufacturer's instructions. Install the detector cable from the Optical Detector on the mast arm to the Phase Selector inside the controller cabinet. Install the wire inside the mast arm and upright and through the underground conduit to the Phase Selector/Controller Cabinet. Do not splice the detector cable.

911.04 Measurement and Payment.

The Engineer shall measure Opticom Priority Control Systems for payment as single units installed and accepted.

The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of the tree or shrub trimming is subsidiary to items for which the Contract provides direct payment. Loading, hauling, construction of all materials, mounting hardware, additional grounding rods, and all miscellaneous hardware is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents. Any costs associated with installing wire/conduit into an existing base/foundation/pad are subsidiary to items for which the Contract provides direct payment. The cost of any training is subsidiary to items for which the Contract provides direct payment. Costs associated with restoration of the surface are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Preemption Control System	Each

912 – WIDE-AREA VIDEO VEHICLE DETECTION SYSTEM

912.01 Description.

This work includes furnishing and installing wide-area video vehicle detection systems including all materials, equipment, labor, tools, transportation, permits, licenses, and all other miscellaneous items necessary to provide an operable system as required by the Contract Documents.

912.02 Material Requirements.

(A) General.

The wide-area video vehicle detection system shall currently be in production. The system shall have a minimum of six (6) months of successful operation at a similar location at the time of the bid opening. Submit a list of users complete with agency name, address, telephone number, and contact person with the bid. Failure to submit the list may result in the rejection of the proposal.

The video detection system shall provide flexible detection zone placement anywhere and at any orientation within the combined field or view of the image sensors. Preferred presence detector configurations shall be lines placed across lanes of traffic or lines placed in-line with lanes of traffic. A single detector line shall be able to replace one or more conventional detector loops connected in series. Design the system to allow overlapping of the detection zones. Detection zones shall have the capability of implementing logical functions including AND, OR, NAND, N of M, and delay/extend timing.

Overall, performance of the video detection system shall be comparable to inductive loop vehicle detectors. The video detection system shall reliably detect vehicle presence when the image sensor is mounted thirty (30) feet or higher above the roadway, when the image sensor is adjacent to the desired coverage area, and when the length of detection area or field of view is not greater than ten (10) times the mounting height of the image sensor.

Using standard image sensing optics without obstructions, the system shall have a minimum vehicle detection accuracy of ninety-eight (98) percent under normal operating conditions. In adverse weather conditions such as shadows, fog, rain, or snow, the minimum vehicle detection accuracy shall be ninety-six (96) percent.

Using standard image sensing optics without obstructions, the system shall have a maximum vehicle count error of four (4) percent under normal conditions. In adverse weather conditions such as shadows,

fog, rain, or snow, the maximum vehicle count error shall be seven (7) percent. Establish the count error over the entire roadway and compile over time intervals containing a minimum of one hundred (100) vehicles.

(B) Image Sensors.

The video detection system shall use medium resolution monochrome or color, image sensors as the video source for real-time vehicle detection.

Each image sensor shall have the following characteristics and capabilities:

- Produce images using a charge coupled device-sensing element with minimum horizontal resolution of three hundred eighty-three (383).
- Output images as a video signal conforming to RS170, RS 170A specifications.
- Produce useable video and resolvable features in the video image for features having a luminance level between one-tenth (0.1) and ten thousand (10,000) lux.
- Produce useable video and resolvable features in the video image when the ratio of the luminance of the resolved features in any single video frame is 300:1.
- Furnish automatic gain, automatic iris, and absolute black reference controls.
- The automatic iris shall operate in a damped manner with a time constant of twenty-five-hundredths (0.25) seconds or longer.
- The automatic gain shall operate in a damped manner with a time constant of one second, and automatic gain shall not be applied to the video signal until the lens aperture is fully opened by the automatic iris control.
- Factory adjust and/or modify the automatic gain, automatic iris, and sensitivity as required for proper performance with the video detection system.
- Adjust the black level to zero (0) IRE units.
- Adjust the iris video level so that a no-contrast image has fifty (50) IRE units of video.
- Adjust the lens ALC to average.
- Include an optical filter and appropriate electronic circuitry for suppressing "blooming" effects.
- The image sensor video signal shall be crystal synchronized or line lock synchronized.
- Preset the image sensor gamma at the factory to a value of one (1.0).
- Equip the image sensor with an auto-iris lens with fixed focal length to suit the site. The maximum aperture of the lens shall not be smaller than f1.8 and the minimum aperture shall not be larger than f300. Pre-focus the image sensor lens at infinity at the factory.

House the image sensor and lens assembly in an environmental enclosure having the following features:

- The enclosure shall be waterproof and dust-tight to NEMA-4 specifications.
- The enclosure shall allow the image sensor to operate satisfactorily over an ambient temperature range from minus thirty-four (–34) degrees Celsius to sixty (60) degrees Celsius while exposed to precipitation and/or direct sunlight.
- The enclosure shall allow rotation of the image sensor horizon during field installation.
- The enclosure shall include a provision for rear connection of power and video signal cables fabricated at the factory.
- Input power to the environmental enclosures shall be 115 VAC 60 Hertz. Allow the option of 240 VAC 50 Hertz.
- Install a heater at the front of the enclosure for preventing ice and condensation formation and assuring proper operation of the lens iris mechanism. The heater shall not interfere with the operation of the image sensor electronics or video signal.
- The enclosure shall be light-colored and shall include a sun shield to minimize solar heating. The front edge of the sunshield shall protrude beyond the front edge of the environmental enclosure. Design the enclosure to divert water flow to the sides of the sunshield. The amount of overhang of the sunshield shall be adjustable to prevent direct sunlight from entering the lens.
- The total weight of the image sensor in the environmental enclosure with sunshield shall be less than three (3) kilograms.
- The image sensor shall meet FCC Class B requirements for electromagnetic interference emissions during operating in the environmental enclosure with power and video signal cables connected.

Isolate the video output of the image sensor from the earth ground. Isolate all video connections from the image sensor to the video interface panel from the earth ground. Provide video lightning protection for individual image sensors.

A brushed aluminum junction box shall be available as an option with each image sensor for installation on the structure used for image sensor mounting. The junction box shall contain a terminal block for terminating power to the image sensor and connection points for coaxial cables from the image sensor and from the machine vision processor.

Place detection zones using a supervisor computer operating in the Windows NT 4.0 or Microsoft Windows 3.1 (or newer versions) graphics environment and a mouse. The VGA monitor shall show images of the detection zones superimposed on the video image of traffic.

Create the detection zones using a mouse to draw detection lines on the supervisor computer's VGA monitor. The detection zones shall be capable of sizing, shaping, and overlapping to provide optimal road coverage and detection. It shall be possible to save the detector configurations on disk, to download detector configurations to the machine vision processor, and to retrieve the detector configuration that is currently running in the machine vision processor.

It shall be possible to use the supervisor's computer's mouse to edit previously defined detector configurations to fine-tune the detection zone placement size and shape. Once creating a detection configuration, the supervisor computer system shall provide a graphic display of the new configuration on its own VGA screen.

When a vehicle is within a detection zone, the zone shall change in color or intensity on the VGA monitor, thereby verifying proper operation of the detection system. Color or intensity changes shall also be used to indicate detection delay and extension timing.

Do not design the image sensor such that mounting directly over the roadway is required. The image sensor shall have the capability to view approaching and departing traffic. A single image sensor placed at a mounting height greater than thirty-three (33) feet and equipped with the proper lens shall be able to minimize vehicle image obstruction and monitor up to eight (8) traffic lanes simultaneously.

(C) Machine Vision Processor.

Design the machine vision processor to be modular and shelf or rack mountable. The machine vision processor shall operate reliably in a typical roadside traffic cabinet. It shall meet the environmental requirements outlined in Standard TS1 and Standard TS2 published by the National Electrical Manufacturers Association, and the environmental requirements for Type 170 and Type 179 controllers. Operating temperature shall be from minus thirty-five (–35) to seventy-four (74) degrees Celsius between zero (0) and ninety-five (95) percent relative humidity, non-condensing.

The machine vision processor shall be capable of simultaneously processing information from up to four (4) closed circuit television video image sensors. The video sources may be, but are not required to be, synchronized or line locked. The machine vision processor shall digitize and analyze the video at a rate of thirty (30) times per second. The machine vision processor shall detect the presence of vehicles using a minimum of one hundred (100) detection zones within the combined field of view of the image sensors. Provide a fifth image sensor input on four camera units as a surveillance video input to be switched as one of five live video sources. It shall be possible to route any of the five video inputs to the video output providing real-time high quality analog video without requiring digital to analog converters.

Once the machine vision processor has been properly set up using the supervisor computer, it shall be possible to disconnect the supervisor computer. The machine vision processor shall detect vehicles as a stand-alone unit, calculate traffic parameters in real-time, and store traffic parameters in its own non-volatile memory.

Design the machine vision processor to compensate for minor camera movement. At a minimum, image stabilization detectors shall minimize the effects of image sensor movement. The machine vision processor shall provide the capability to link the analog video image to the digital detector layout as reference information for stabilization. Stabilization shall only be required if there is a motion problem observed by the user. Each detection orientation shall allow the placement of one (1) to five (5) image stabilizers in the video image.

The machine vision processor shall count vehicles in real-time and compute the average of traffic parameters over user-defined time intervals (or time slices), as follows:

- Volume.
- Number of vehicles detected during the time interval.
- Occupancy.
- Lane occupancy measured in percent of time.
- Vehicle Classification.
- Number of automobiles, single unit trucks, or tractor-trailers, as defined by length.
- Flow Rate.
- Vehicles per hour per lane.
- Headway.
- Average time interval between vehicles.
- Speed.
- Time and space mean vehicle speed in miles per hour or kilometers per hour.
- Level of Service.
- Determination by user defined thresholds for average speed and flow rates.
- Space Occupancy.
- Sum of the vehicle lengths divided by average distance traveled during the time interval measured as percent.
- Density.
- Average flow divided by space average speed. Express in vehicles/miles or vehicles/kilometer.

The duration of the time intervals (or time slices) shall be user-selectable as 1, 5, 10, 15, 30, or 60 minutes.

Retain the time-interval data in non-volatile EPROM flash memory within the machine vision processor for later transfer to the supervisor

computer for analysis. The minimum amount of memory shall be four (4) megabytes.

Accomplish retrieval of data stored in the non-volatile memory of the machine vision processor using a serial communications port. Incorporate provisions for transfer of data via a modem and dial-up telephone lines (standard phone line), via private cable or fiber optic network, or via direct connection to another computer by cable.

Once the detector configuration has been downloaded from the supervisor computer into the machine vision processor, it shall be possible to operate the video detection system with the supervisor computer disconnected or on-line.

Power the machine vision processor by eighty-nine (89) to one hundred thirty-five (135) VAC, sixty (60) hertz, single phase, drawing a maximum of twenty-five-hundredths (0.25) amps, or by one hundred ninety (190) to two hundred seventy (270) VAC, fifty (50) hertz, single phase, drawing a maximum of twelve-hundredths (0.12) amps. The power supply shall automatically adapt to the input power level. Include transient protection sufficient to meet the requirements outlined in NEMA Standard TS1 and Standard TS2. Provide power to the machine vision processor from the transient protected side of the AC power distribution system in the traffic control cabinet.

The machine vision processor shall provide processing capability equivalent to the Intel 486SX microprocessor or greater as required by the Engineer. Verify the processing capability requirements with the Engineer before ordering or obtaining the machine vision processor. The bus connections used to interconnect the modules of the machine vision processor shall be gold-plated DIN connectors. Use an RS-232/RS-422 serial port for serial communications to the supervisor. Use a nine (9) pin "D" subminiature connector on the front of the machine vision processor for serial communications. The RS-232/RS-422 serial port shall be able to download the traffic data stored in the non-volatile memory and the real-time detection information needed to show the detector actuation.

Equip the machine vision processor with a NEMA TS1 detector interface with thirty-two (32) detector outputs. The output level shall be compatible with the NEMA TS1, NEMA TS2 Type 2, Type 170, and Type 179 standards. Use a thirty-seven (37) pin "D" subminiature connector on the front of the machine vision processor for interfacing to these outputs.

Equip the machine vision processor with a NEMA TS2, Type 1 detector interface if detector information is transmitted serially using an RS-485 data path. Use a fifteen (15) pin "D" subminiature connector meeting the requirements of the standard for the serial detector output.

Provide NEMA red/green inputs for up to sixteen (16) phases as inputs to provide controller state information for detection and extend/delay timing functions. Use a thirty-seven (37) pin "D" subminiature connector on the front of the machine vision processor for these inputs.

Equip the machine vision processor with up to four (4) RS-170 (black and white)/NTSC (color) composite video inputs to allow signals from up to four (4) image sensors or other synchronous or non-synchronous video sources to be processed in real-time. Provide a fifth video input to allow connection of a local surveillance camera or other non-detection video source. Do not use the video from this auxiliary video input for detection. Use BNC connectors on the front of the machine vision processor for all video inputs.

Equip the machine vision processor with one (1) RS170/NTSC composite video output capable of switching to correspond to any of the video inputs selected using the supervisor computer or the front panel switch. Multiple video outputs requiring external cable connection to create a combined single video output are not acceptable. Equip the machine vision processor with CCIR (black and white)/PAL (color) format video inputs and outputs. Use a BNC connector on the front of the machine vision processor for video output.

Store the machine vision processor software in flash memory within the machine vision processor. Design the machine vision processor to allow software updating without removing any modules or memory devices. Include diagnostic software for testing the machine vision processor functions with machine vision processor and/or the supervisor. Diagnostic software shall include the capability to set and clear individual detector outputs as well as display the status of inputs to enable setup and troubleshooting in the field.

Accomplish communications with the supervisor computer using a point-to-point, multi-drop, or standard telephone line communication. Use a distinctive ring switch when using the same telephone line to communicate with the traffic controller and the machine vision processor. Use a dial up modem when using a separate telephone line to communicate with the traffic controller and the machine vision processor. Use an error checking and retransmission protocol for file transfer operations. Communication equipment shall allow digital video to transmit to a remote supervisor computer using standard telephones lines at a minimum speed of five (5) frames per second.

Include the capability to capture a video image from the selected image sensor input and transmit the image to the supervisor computer for display. Compress the captured video image to minimize the transmitting time. Provide the option to allow detection to suspend or continue during compression and transmission of the captured image.

(D) Video Isolation Amplifier.

Design the video isolation amplifier to buffer the video signal, provide transient suppression, and provide coaxial cable connection points. Include an EDCO CX06-BNCY or approved equal transient suppresser for each image sensor.

(E) System Software.

The system software shall detect approaching or receding vehicles in multiple traffic lanes. With a machine vision processor capable of handling four image sensors, there shall be a minimum of 100 detection zones that can be user-defined through interactive graphics by placing lines and/or boxes in an image on a VGA monitor. The user shall be able to redefine previously defined detection zones. The machine vision processor shall calculate traffic parameters in real-time and provide local non-volatile data storage for later downloading and analysis.

This supervisor software shall provide an easy-to-use graphical user interface and support all models/versions of the supplied machine vision processor. The software shall support both still image and real-time viewing of video images within a window. Provide the collected traffic and detection data in readily accessible American Standard Code for Information Interchange format. The supervisor computer software shall provide file management routines for efficiently filing, retrieving, and reporting of the collected traffic data. The supervisor computer software shall have passwords and multiple security levels of operation. Supervisor software shall use a Windows 3.1, Windows NT 4.0, or Windows 95 operating system. The Engineer reserves the right to approve the use of newer Windows operating systems. Supply the appropriate operating system as directed by the Engineer.

Do not require a video digitizer board for detector programming. Include a video digitizer for all supervisor computers and configure the supervisor computer system to allow the display of real time video.

It shall be possible to display the captured traffic data on the VGA screen of the supervisor computer in numeric format. The data displayed shall be for the last complete interval. Selection of the data to be displayed shall be by pull-down menus and shall be in the form of windows under the Microsoft Windows NT 4.0, Windows 3.1, or newer version graphics operating environment.

(F) Supervisor Computer.

The minimum supervisor computer system consists of a notebook computer including a LCD display supporting 256-color operation, a docking station for field use, and Windows-based operating software. Configure the software to allow the following:

- Video vehicle detection real-time viewing using the supervisor computer's display when the supervisor computer is on-line.

- Capturing and storing the video image displayed as a file on the supervisor computer.
- Storing the time-interval traffic data and the complete time data or actuation data on the supervisor computer.

If selectable via software, detector types shall include count detectors, presence detectors, directional presence detectors, speed detectors, station detectors, input detectors, and detector logical functions. The speed detectors shall report vehicle speed and vehicle classification based on length. Three length categories shall be user-definable in software.

(G) Miscellaneous Hardware.

Supply all necessary cables, brackets, and hardware conforming to the manufacturer's recommendations. Coaxial cable shall be a low loss seventy-five (75) ohm precision video cable suited for outdoor installation. Mating cables shall be a single eighteen (18) circular metal shell connector (Bendix PT07C-14-18P or equivalent) using a right angle shell and available in lengths of five (5), ten (10), thirty-three (33), and sixty-six (66) feet to accommodate various installations

(H) Warranty, Maintenance, and Support.

Provide all product documentation. Documentation shall be written in the English language. The supplier shall provide a minimum two (2) year guarantee on the video detection system beginning on the date of acceptance and approval for payment by the City. During this two (2) year period, the supplier shall provide the City continuous hardware and software support including any updates of the machine vision processor or system software at no additional cost. The supplier shall provide technical support, via telephone, within four (4) hours of a request by the City. Factory-certified personnel or installers shall provide such support. The supplier shall negotiate a separate agreement with the City for continued technical support and upgrades following the expiration of the warranty period.

The supplier shall maintain a program for technical support updates following expiration of the warranty period. Coordinate this program with the City of Omaha in the form of a separate agreement for continuing support.

912.03 Construction Requirements.

(A) General.

Before ordering materials and within fifteen (15) calendar days after the award date, submit the information required by Table 912.01 for all materials. The Contractor is liable for any materials purchased before receiving written approval from the Engineer. Use new, unused, and in first class condition materials for the construction of the traffic signal system unless specifically stated otherwise in the Contract Documents.

At the time of each submittal, identify in writing any deviations that the shop drawings or samples may have from the requirements of the Contract Documents.

Table 912.01
Materials Information Requirements

Item	Required Information
Image Sensors	Manufacturer's Model or Catalog Number, Working Drawing*, Certificate of Compliance, Mill Test**, Design Calculation**
Machine Vision Processor	Manufacturer's Model or Catalog Number
Video Isolation Amplifier	Manufacturer's Model or Catalog Number, Certificate of Compliance
System Interface	Manufacturer's Model or Catalog Number, Certificate of Compliance

* As required by the Engineer
** May substitute catalog number or model number for shop drawing as permitted by the Engineer

Do not construe Engineer's acceptance of a submittal as relieving the Contractor of the responsibility to comply with the Contract Documents. The City shall reimburse the Contractor for all other items upon completion and acceptance of the work. Obtain all training, licenses, and permits before commencing the work.

Wire all circuits as required by the Contract Documents, clear of faults, grounds, and open circuits. Connect the service neutral conductor and all interconnected equipment grounding conductors solidly to a driven ground rod at the traffic signal service disconnect pedestal. Installations shall comply with all applicable sections of the National Electrical Code, National Electrical Safety Code, Manual on Uniform Traffic Control Devices, all governing local ordinances and regulations, and the Contract Documents. The Engineer shall resolve any conflicts.

Inform the Engineer of the work scheduled each day. Schedule work to minimize the time any signal is inoperable. During this time, provide, place, and maintain temporary traffic control devices in accordance with the City of Omaha's "Manual of Barricading Standards, Specifications, Methods, and Materials". Maintain a minimum of two (2) lanes of traffic on one-way streets and one (1) lane of traffic in each direction on two-way streets open to traffic during the work. Open all lanes to traffic during peak hours as directed by the Engineer or Contract Documents. Maintain traffic through open intersections at all times.

Coordinate work with all other phases of the project to minimize conflict between combined operations. Schedule work and materials deliveries to meet the project schedule. Provide the utility company supplying the electrical service adequate notice regarding the scope and nature of the power requirement. Arrange for all necessary electrical services at locations indicated in the Contract Documents. The utility company or Engineer may alter the service location in the field to adapt

to certain field requirements. Cooperate with the utility company providing electrical service in locating the service lines and conduit bends.

Trim trees or shrubs using proper tree surgery practices to trim tree branches as necessary to install the poles, mast arms, span wires, or pole. Use an asphaltum-based paint manufactured for tree surgery to treat the cut or scarred branches.

Do not disconnect or damage an operational communication cable while performing work around traffic signal systems without written permission from the Engineer. Reconnect, repair, or establish a temporary connection within eight (8) hours of disconnecting or damaging a communication cable.

Size conduit bends installed in existing foundations to be equivalent to the connecting conduit in the ground. Do not cut or damage the reinforcing steel or anchor bolts in the foundation. Install the conduit a minimum depth of twelve (12) inches below the top of the foundation or thirty (30) inches below the depth of the surrounding ground surface, whichever is greater. Remove a sufficient amount of concrete to place the conduit inside the anchor bolts of the foundation. Position the conduit and place concrete or grout. Finish to match the existing foundation.

Replace or restore in kind equal to or exceeding any surface materials disturbed by trenching, excavating, or backfilling operations. Accomplish restoration in accordance with the Contract Documents. Dispose of all excess materials as directed by the Engineer.

Activate and operate the system in normal fashion as soon as possible if the road is open to public travel at the time the installation or any workable segment of the installation is completed. Notify the Engineer a minimum of forty-eight (48) hours before putting the system into operation. Do not put the system into operation without the Engineer present. Secure the services of a person qualified to operate and adjust the system. Test the circuits installed before activating the system.

Before final acceptance, demonstrate by tests to the Engineer's satisfaction that all installations are in proper condition as required by the Contract Documents. Do not construe operation of the system as acceptance of the system, acceptance of any part of the system, or as a waiver of any contract provisions. All electrical installations are subject to a thirty (30) day trial period before the Engineer may consider the installation for acceptance. The City shall pay for electrical energy consumed by the system during the thirty (30) day operational trial period. Transfer any guarantees or warranties on materials purchased to the City upon acceptance of the work. Purchase materials with transferable guarantees or warranties.

After the system is turned on and operating satisfactorily, the City shall assume responsibility for routine maintenance. Maintenance activities by the City do not relieve the Contractor of any responsibility for failures due to workmanship or materials that occur before final acceptance of the project. The Engineer shall decide the responsibility of the Contractor relating to any failure occurring before final acceptance.

Notify the Engineer one (1) week before changing any approach lanes using video detection during construction to allow for reprogramming of the video detection system.

(B) System Installation.

Install the system in accordance with the manufacturer's instructions. Proper instruction from certified instructors is required to ensure that the end-user has complete competency in system operation. The User's Guide is not an adequate substitute for practical classroom training and formal certification by an approved agency. Formal levels of authorized training are required for installers, contractors, and system operators. Installers, contractors, and system operators unable to attend formal training sessions shall arrange for the appropriate level of training and certification independently at no additional cost to the City. Provide proof of training to the Engineer before beginning any installation. Any required training shall be part of the bid price and will not be paid for separately.

The supplier of the video detection system shall supervise the installation and testing of the video detection system and computer equipment. A factory-certified representative from the supplier must be on-site during installation.

Install the supervisor computer software on all the supervisor computers including up to four (4) City-owned desktop computers located at 1819 Farnam Street and 4303 S. 50th Street. Install these video digitizer boards on all supervisor computers and provide a docking station.

Connect the image sensor to the machine vision processor such that the video signal originating from the image sensor is not attenuated more than three (3) decibels when measured at the machine vision processor. Do not splice the coaxial cable between the video interface panel or video isolation amplifier and the junction box. Connect the video outputs and power inputs to the image sensor using a mating cable.

Install a video isolation amplifier instead of the video interface panel as needed in accordance with the manufacturer's instructions. Connect the shield side of the coaxial cable connection at the transient suppresser to the earth ground using the transient suppresser.

Install a distinctive ring switch when using the same telephone line to communicate with the traffic controller and the machine vision processor. Provide a separate dial up modem and telephone drop as needed.

(C) System Training.
Provide installation and training support using factory-authorized representatives. Provide eight (8) hours of training to City of Omaha personnel at a location selected by the Engineer. Training shall incorporate the operation, setup, and maintenance of the video detection system. Provide instruction manuals and materials for a maximum of 6 (six) persons.

912.04 Measurement and Payment.

The Engineer shall measure wide-area video vehicle detection system for payment as single units installed and accepted.

The cost of any design, licenses, or permits associated with the work is subsidiary to items for which the Contract provides direct payment. The cost of the tree or shrub trimming is subsidiary to items for which the Contract provides direct payment. Supplying and installation of all materials, mounting hardware, additional grounding rods, video isolation amplifiers, operating systems, dial-up modem, telephone drop, and all miscellaneous hardware is subsidiary to the installation of the specific item unless otherwise indicated in the Contract Documents. Any costs associated with installing wire/conduit into an existing base/foundation/pad are subsidiary to items for which the Contract provides direct payment. The cost of any training is subsidiary to items for which the Contract provides direct payment. Costs associated with restoration of the surface are subsidiary to items for which the Contract provides direct payment.

Payment will be made under the following unless otherwise indicated in the Contract Documents. This price shall be full compensation for the cost for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Wide-Area Video Vehicle Detection System	Each

THIS PAGE INTENTIONALLY LEFT BLANK

1000 MISCELLANEOUS ITEMS

1001 – PUBLIC INFORMATION SERVICES

1001.01 Description.

This work shall include providing public information services from commencement to final completion of the work outlined in the Contract Documents.

1001.02 Material Requirements.

None.

1001.03 Construction Requirements.

Designate a single person employed or sub-contracted by the Contractor as the individual responsible for maintaining communications with the Engineer and local residents and businesses. This individual shall provide information to local residents and businesses on a regular interval as directed by the Contract Documents or determined by the Engineer. Provide a public office open a minimum of four (4) hours each working day that is equipped with a local call line and an answering service. The answering service shall allow callers to leave a message and provide callers information on office hours and current and future work. Monitor the answering service a minimum of one (1) time every twelve (12) hours. The Contractor's regular office call line or cellular telephone lines are acceptable provided such lines are local call lines.

The designated individual shall respond to all questions concerning activities and schedules of the work and participate in all meetings pertaining to the work between local residents and businesses, the Engineer, and the Contractor. Maintain a log of local resident and business contact names, addresses, and telephone numbers. Document all meetings and conversations and any subsequent action taken and provide such documentation to the Engineer upon request.

Prepare and distribute fliers to local residents and businesses directly adjacent to the limits of the project a minimum of seven (7) days before commencing the work. The flier shall identify the designated contact person, location of the public office, hours of the public office, local call line, scope of the work, anticipated start and completion dates, and detailed schedule for the first twenty (28) days.

1001.04 Measurement and Payment.

The Engineer shall measure public information services for payment as a lump sum item defined by the public information services provided and accepted.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for providing public offices, local call lines, answering services, and documentation; for providing and maintaining a log; for supplying and distributing fliers; and for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Public Information Services	Lump Sum

1002 – SPRINKLER SYSTEM RELOCATION/REPLACEMENT

1002.01 Description.

This work includes removing, installing, relocating, reconnecting, and repairing sprinkler systems.

1002.02 Material Requirements.

Sprinkler system components and materials shall match existing sprinkler system components for existing systems. Sprinkler system components and materials for new installations shall be a commercially manufactured sprinkler system acceptable to the Engineer.

1002.03 Construction Requirements.

(A) General.
Individuals or firms routinely engaged in lawn sprinkler installation and repair shall perform all sprinkler system removal, installation, relocation, reconnection, and repair work.

(B) Removal.
Remove sprinkler systems including heads, lines, and control boxes to the limits identified in the Contract Documents or indicated by the Engineer. Preserve all removed components to allow for reinstallation. Remove trunk lines at locations directed by the Engineer. Install caps at locations acceptable to the Engineer on all remaining lines to permit use of all remaining portions of the system. Adjust remaining sprinkler system heads to avoid damage to the work as allowed by the Engineer. Install caps on all abandoned lines left in place.

(C) Installation, Relocation, and Reconnection.
Install sprinkler systems in accordance with the manufacturer's recommendations. Install new or relocated trunk lines at locations directed by the Engineer. Adjust the sprinkler system heads efficiently to water the area or to duplicate the pre-construction watering pattern for removed and reinstalled sprinkler heads.

(D) Repair.
Install caps on all damaged sprinkler systems and notify the Engineer and property owner immediately after damaging. Repair any damaged sprinkler systems within twenty-four (24) hours of damaging. Repair damaged lines by exposing the damaged area and installing a watertight splice. Repair damaged sprinkler system heads by removing and replacing the damaged head with a sprinkler head of the same type and manufacturer. Repair damaged sprinkler systems at no additional cost to the City unless otherwise indicated in the Contract Documents or directed by the Engineer in writing.

1002.04 Measurement and Payment.

The Engineer shall measure removal of sprinkler system heads and lines for payment as a single unit defined as the number of sprinkler system heads removed and accepted.

The Engineer shall measure installation of new sprinkler system heads and lines for payment as a single unit defined as the number of sprinkler system heads supplied, installed, and accepted.

The Engineer shall measure removal, relocation, and reconnection of sprinkler system heads and lines for payment as a single unit defined as the number of sprinkler system heads removed, relocated, and accepted.

The Engineer shall measure removal, relocation, and reconnection of sprinkler system trunk lines for payment as a single unit defined as the number of linear feet of sprinkler system trunk line removed, relocated, and accepted.

The Engineer shall measure removal of sprinkler system control boxes for payment as a single unit defined as the number of sprinkler system control boxes removed and accepted.

The Engineer shall measure installation of new sprinkler system control boxes for payment as a single unit defined as the number of sprinkler system control boxes supplied, installed, and accepted.

The Engineer shall measure removal, relocation, and reconnection of sprinkler system control boxes for payment as a single unit defined as the number of sprinkler system control boxes removed, relocated, and accepted.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for removal and capping of the existing system, preservation of removed heads and appurtenances, and replacement of heads damaged during removal; for providing and installing control systems, new distribution pipes/system, new sprinkler heads, and connections to water sources; and for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	Unit
Remove Sprinkler System Head	Each
Install Sprinkler System Head	Each
Remove and Relocate Sprinkler System Head	Each
Remove and Relocate Sprinkler System Trunk Line	Linear Foot
Remove Sprinkler System Control Box	Each
Install Sprinkler System Control Box	Each
Remove and Relocate Sprinkler System Control Box	Each

1003 – MAILBOXES

1003.01 Description.

This work includes removal, temporary relocation, reinstallation, and/or replacement of mailboxes and posts.

1003.02 Material Requirements

Mailboxes and posts shall conform to the requirements for mailboxes as defined by the United States Postal Service Postal Operations Manual 632. Replacement mailboxes are subject to the approval of the Engineer before installation.

1003.03 Construction Requirements

Remove and salvage mailboxes and posts in a manner to preserve said items for re-use. Replace mailboxes or posts that the Engineer deems unacceptable for reuse. The Engineer shall approve replacement mailboxes or posts before installation. Repair or replace to the satisfaction of the Engineer any mailboxes or posts damaged by negligent actions of the Contractor.

Install and maintain temporary mailboxes at the locations indicated in the Contract Documents. Install temporary mailboxes at the proper height as directed by the United States Postmaster. Anchor temporary mailboxes to prevent unintentional movement.

Install new or relocated mailboxes at the final locations as indicated in the Contract Documents. Install such mailboxes at the proper height and locations as directed by the United States Postmaster or the Engineer.

1003.04 Measurement and Payment.

The Engineer shall measure the removal, installation of temporary mailboxes, and installation of permanent mailboxes for payment as a single unit defined as the number of mailbox posts installed and accepted. Attaching mailboxes to the posts, regardless of the number of mailboxes attached to an individual post, is subsidiary to items for which the Contract provides direct payment.

The Engineer shall measure the replacement of mailboxes deemed unacceptable at no fault of the Contractor for payment as a single unit defined by the number of replacement mailboxes supplied, installed, and accepted.

The Engineer shall measure the replacement of mailbox posts deemed unacceptable at no fault of the Contractor for payment as a single unit

defined by the number of replacement mailbox posts supplied, installed, and accepted.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Remove and Replace Mailbox	Each
Furnish Mailbox	Each
Furnish Mailbox Post	Each

1004 – FIELD OFFICE

1004.01 Description.

This work includes furnishing and placing a field office of the type or types specified in the plans or proposal at the project or plant site for the exclusive use of and control by the Engineer for performing testing required to control the work, for making reports, and for proper storage of equipment and project records.

1004.02 Material Requirements.

(A) General Requirements.

Field offices shall consist of a suitable wood, metal-covered wood, metal, masonry block, or other structure acceptable to the Engineer. The laboratory shall be floored, completely insulated, and maintained dust and weather tight. Provide screens and suitable locks on all outside doors and windows.

Furnish constant electricity (120, 220, and 240 volts AC as required) to the field office sufficient to power lights, heating and cooling systems, and all necessary equipment. Maintain the electricity during non-working hours as required by the Engineer. Furnish potable water as required by the Engineer. Equip the field office with a suitable heating and cooling system capable of maintaining the inside temperature between sixty-five (65) and eighty (80) degrees Fahrenheit. Furnish all necessary fuel or other energy sources required by the heating system.

Equip each office with a commercial Underwriters' Laboratory approved fire extinguisher capable of controlling fires of paper, wood, rubbish, etc. Service and maintain the fire extinguishers in a full and operative condition at all times during the use of the office.

(B) Type A Field Office.

Type A field offices shall have a minimum interior dimension of nine (9) feet wide and seven (7) feet high with a minimum floor area of two hundred twenty-five (225) square feet. Equip Type A field offices with a minimum of two (2) exterior doors and four (4) sliding- or swinging-type windows. Subdivide the interior into a minimum of two (2) rooms separated by a full-height wall and standard door and having a minimum floor area of fifty-four (54) square feet and one (1) exterior door and one (1) exterior window. Each room shall have a minimum of twelve (12) square feet of suitable workbench capable of supporting a minimum of two hundred (200) pounds along any two (2) foot linear section. Locate the workbench surface between thirty-six (36) and forty-eight (48) inches above the office floor. Furnish a minimum of eight (8) conveniently located duplex wall outlets installed at a height above the workbench surface. Equip one (1) room with an exhaust fan

located above the workbench and a pressure or gravity-flow potable water system, a sink, faucet, and drainage system acceptable to the Engineer.

(C) Type B Field Office.
Type B field offices shall have a minimum interior dimension of seven (7) feet wide and seven (7) feet high with a minimum floor area of one hundred forty-seven (147) square feet. Equip Type B field offices with a minimum of one (1) exterior door and two (2) sliding- or swing-type windows. Furnish a minimum of twenty-four (24) square feet of suitable workbench capable of supporting a minimum of two hundred (200) pounds along any two (2) foot linear section. Locate the workbench surface between thirty-six (36) and forty-eight (48) inches above the office floor. Furnish a minimum of eight (8) conveniently located duplex wall outlets installed at a height above the workbench surface. Equip the office with an exhaust fan located above the workbench and a pressure or gravity-flow potable water system, a sink, faucet, and drainage system acceptable to the Engineer.

(D) Type C Field Office.
Type C field offices shall have a minimum interior dimension of seven (7) feet wide and seven (7) feet high with a minimum floor area of ninety-one (91) square feet. Equip Type C field offices with a minimum of one (1) exterior door and two (2) sliding- or swing-type windows. Furnish a minimum of twenty-four (24) square feet of suitable workbench capable of supporting a minimum of two hundred (200) pounds along any two (2) foot linear section. Locate the workbench surface between thirty-six (36) and forty-eight (48) inches above the office floor. Furnish a minimum of eight (8) conveniently located duplex wall outlets installed at a height above the workbench surface. Equip the office with an exhaust fan located above the workbench and a pressure or gravity-flow potable water system, a sink, faucet, and drainage system acceptable to the Engineer.

1004.03 Construction Requirements.

Place the building level and solidly supported at locations near the work, away from sources of vibration, and acceptable to the Engineer. Relocate the field office building as necessary due to progress of the work or as directed by the Engineer.

1004.04 Measurement and Payment.

Field offices, all related utilities and services, and all other work associated with field offices shall be subsidiary to items for which the Contract provides direct payment.

1005 – BRICK PAVEMENT AND SIDEWALK

1005.01 Description.

This work includes supplying and constructing a brick pavement, brick sidewalk, and sand fill on a prepared base course along the lines, grades, and dimensions indicated in the Contract Documents or as directed by the Engineer.

1005.02 Material Requirements.

(A) Brick Pavers.
Brick pavers shall conform to the requirements of ASTM C216, Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale). The Engineer shall approve of all used brick pavers before incorporation into the work. Remove all earth, mortar, asphalt, oil, or other foreign material from the used brick pavers using a wire brush or other methods acceptable to the Engineer. Do not use worn, broken, or otherwise damaged used brick pavers.

(B) Cushion Sand.
Cushion sand shall be a granular, non-plastic, uncrushed aggregate with a maximum particle size of one-fourth (¼) inch and a maximum of three (3) percent passing a No. 200 standard sieve. Cushion sand shall meet all physical property requirements for fine aggregate as defined by ASTM C33, Standard Specification for Concrete Aggregates.

(C) Mortar.
Mortar shall consist of one (1) part Portland cement and four (4) parts sand. The Portland cement shall conform to the requirements for Cement Type I as defined by ASTM C150, Specification for Portland Cement including Table 1, Table 2 (Maximum Equivalent Alkalies requirements only), and Table 3. The sand shall conform to the requirements of ASTM C144, Standard Specification for Aggregate for Masonry Mortar.

1005.03 Construction Requirements.

Use equipment having sufficient capacity and designed for the proposed use. Plate vibrators shall have a minimum plate area of three hundred (300) square inches and a centrifugal force of approximately one (1) ton per each three hundred (300) to five hundred (500) square inches.

Uniformly spread and compact the cushion sand to form a smooth, level layer having a thickness of two (2) inches after compaction. Place the brick pavers atop the compacted cushion sand in the pattern indicated in the Contract Documents or as directed by the Engineer. Place subsequent brick pavers firmly against the adjacent pavers in a manner that adjacent bricks fit

closely together. Position the brick paver by holding the brick paver slightly above the cushion sand without disturbing the sand until the block is in the correct position.

Close open joints using a hide mallet or other methods acceptable to the Engineer. Do not tilt brick pavers on the leading edge of the laying face by allowing workers to stand or kneel on the brick pavers. Continue brick placement until sufficient area is available for vibrating. Avoid disturbing the pavers before vibrating. Correct uneven surfaces after vibrating in a manner acceptable to the Engineer. Cut pavers to fit along pavement edges, manholes, valve boxes, and miscellaneous obstacles as necessary. Do not place cut edges in interior areas of the brick pavement. Use mortar to fill gaps less than two (2) inches wide.

Vibrate the pavers to the final level using a plate vibrator. Guide the plate vibrator over the area, avoiding any restrained edges by about a yard. Brush dry cushion sand over the surface of the pavers after the initial passes of the plate vibrator to fill minor gaps between pavers. Continue vibrating to obtain maximum settlement, as determined by the Engineer. To ensure that the cushion sand level is correct, place a full-width layer of brick pavers to the finished surface elevation and check after completion of the first five (5) feet and at frequent intervals thereafter. If the final level of the brick pavement is incorrect, remove the brick pavers and rake, re-screed, and re-compact the cushion sand to the required level. Re-position the brick pavers to the correct grade, vibrate, and fill the joints with cushion sand. Remove excess cushion sand from the surface.

1005.04 Measurement and Payment.

The Engineer shall measure brick pavement for payment as a single unit defined by the number of square yards of brick pavement supplied, constructed, and accepted.

The Engineer shall measure brick sidewalk for payment as a single unit defined by the number of square feet of brick sidewalk supplied, constructed, and accepted.

The Engineer shall measure brick edging for payment as a single unit defined as the number of linear feet of brick edging supplied, constructed, and accepted.

Cushion sand shall be subsidiary to items for which the Contract provides direct payment.

Payment shall be made under the following unless otherwise indicated in the Contract Documents. The Contract Price shall be full compensation for supplying and installing all brick pavers, cushion sand, forms, and expansion joints; for cleaning used brick pavers; and for furnishing all

labor, materials, equipment, tools, and incidentals necessary to complete the work.

Description	**Unit**
Brick Pavement	Square Yard
Brick Sidewalk	Square Foot
Brick Edging	Linear Feet

THIS PAGE INTENTIONALLY LEFT BLANK

INDEX

Advance warning systems ..... See Signs, Barricades

Aggregate
Base 113, 114
Granular Foundation Course 100
Subbase 113, 114
Surface 117

Appurtenances 321
Aggregate Bedding 325
Backfill 339
Bedding 329
Connections 338
Flowable Fill Backfill 341
Grout 325
Installation 329
Invert Channels 337
Mortar 324
PCC 321, 325
Wye Branches 338

Asphaltic Concrete Curb
Anti-stripping Agents 144
Asphalt Binder 143
Asphalt Release Agent 143
Coarse Aggregate 143
Construction 147
Curbing Machine 145
Fine Aggregate 143
Hauling Equipment 145
Mineral Filler 143
Mix Design 144
Mixing Plant 145
RAP 144
Surface Preparation 146
Tack Coat 143
Weather 146

Asphaltic Concrete Pavement 129
Aggregate 91
Anti-Stripping Agents 130
Asphalt Binder 91, 130
Asphalt Paver 134
Asphalt Release Agent 129
Coarse Aggregate 130
Compaction Equipment 134
Compaction Requirements 137
Construction 136
Fine Aggregate 130

Hauling Equipment....134
Mineral Filler....92, 130
Mix Design....92, 131
Mixing Plant....133
Pay Factors....140
RAP....130
Recycling Agents....131
Surface Preparation....135
Weather....134

Barricades.... 527, 528
Temporary Sign Drums....528

Barrier Curb.... 217
Precast....227
Pre-cast....219

Bituminous Surface Treatment.... 151
Cover Aggregate....151
Cutback Asphalt....151
Emulsified Asphalt....151

Borrow Materials.... 99, 307, 325

Box Culverts.... 231
Aggregate Bedding....231
Aluminum....231, 236
Backfill....242
Bedding....235
Flowable Fill Backfill....243
PCC Cast-in-Place....236
Precast PCC....231, 236
Steel....231, 236

Brick
Bricks....595
Cushion Sand....595
mortar....595
Removal....85

Clearing and Grubbing.... 63

Clearing of Tracts.... 67

Crack Repair.... 91
Fabric....91
Type A....94
Type B....94
Type C....96

Curb Grinding **193**

Electrical Cable **503**
Backfill 510
Conduit 503
Grounding Wires 503
Installation 511
Installation – Conduit 513
Installation – Direct Burial 514
Installation – Overhead 512
Lubricant 504
Pull Boxes 504, 508
Structures 508
Trench Installation 508
Trench-less Installation 508

Embankment **99, 101**

Emulsion/Aggregate Slurry **91**

Erosion and Pollution Controls
Articulated Block 423
Gabion Baskets 427
Revet Mattresses 427
Temporary 417

Erosion Control, Rolled **409**
Burlap Fabric 411
Coconut Mats 412
Fertilizer 410, 415
Hay or Straw Blankets 410
Installation 415
Mulch Blankets 412
Seed 410, 415
Straw and Coconut Mats 411
Synthetic Mats 412
Synthetic Mesh 413
Turf Reinforcement Mats 413
Wire Staples 414
Wood Excelsior Blankets 411

Erosion Control, Temporary
Area Inlet Filters 418, 420
Area Inlet Protection 421
Curb Inlet Protection 421
Filter Aggregate 418
Granular Inlet filters 418
Granular Inlet Filters 420
Hay Bales 417, 420
Hay Inlet Filters 418, 420
Posts 417
Silt Dikes 418, 420
Silt Fence 417, 419
Support Fence 417

Temporary Berms 419, 420
Wire Staples 418

Excavation 99, 100, 234, 261, 274, 285, 328, 360
Unsuitable 101

Expansion Joints
Pre-formed 164, 179, 194, 287

Fence 431
Bollards....435, 437
Chain Link 431, 436
Grounding 435, 436
PVC....433, 437
Remove and Reset....437
Wood 432, 437

Field Office 37, 593
General....593
Type A 593
Type B 594
Type C 594

Final Payment 60

Flowable Fill 74, 77, 111, 307
Admixtures 74, 111, 232, 248, 326
Aggregate 73, 111, 232, 247, 326
Fly Ash 74, 111, 232, 247, 326
Mix Design 111, 233, 249, 327
Portland Cement 73, 111, 247, 326
Water 74, 111, 232, 247, 326

Fly Ash
Slurry....75
Stabilization....109

Fog Seal
Emulsified asphalt 155

Gabion Baskets
Fill Material 427
Geotextile fabric....428
Wire mesh baskets 428

Geotextile Fabric 114, 124, 253
Installation....115, 126

Geotextile Grid 113, 123, 253
Installation....115, 126

Guardrail **245**
Approach Sections 246
Cable 247
Cable Hardware 247
Elements 246
Fittings 246, 247
Joints 247
Offset Blocks 245
Sealing Compound 249
Splices 247
Steel Posts 246
Terminal Sections 246
Wood Posts 245

Inlets **321**
Adjustment 338
Aggregate Bedding 325
Backfill 339
Bedding 329
Connections 338
Construction 331
Flowable Fill Backfill 341
Grout 325
Invert Channels 337
Metal Grates 322
Mortar 324
PCC 321, 325

Joint Filler **91, 324**
Pre-molded 161, 176, 190, 260, 273, 284, 396, 446, 461, 533

Joint Mortar **324**

Joint Repair **91**
Type A 94
Type B 94
Type C 96

Joint Sealant **161, 176, 190, 397**

Joints
Pressure Relief 161, 176, 180, 194, 399

Low Strength Concrete **75**
Admixtures 74, 205
Aggregate 205
Coarse Aggregate 73
Construction Joints 213
Contraction Joints 213
Curing materials 206
equipment 207
Fly Ash 205
forms 208

Mix Design 206
Opening/Using 214
Placing 208
Portland Cement 73, 205
Thickness 214
Water 74, 205

Mailboxes 591

Manholes 321
Acceptance Testing 341
Adjustment 338
Adjustment Risers 324
Aggregate Bedding 325
Backfill 339
Bedding 329
Brick 321, 331
Castings 321
Connections 338
Construction 331
Covers 321
External Wraps 324
Flowable Fill Backfill 341
Frame Seals 339
Frame Seals and Extensions 322
Grout 325
Installation 329
Invert Channels 337
Metal Grates 322
Mortar 324
PCC 321, 325
PCC Masonry Unit 331
PCC Masonry Units 321
Rings 321
Steps 321
Stub-outs 337

Mowing 65

Mulch 389
Emulsified Asphalt 389
Hay or Straw 370, 373, 389, 391
Hydraulic 371, 374, 390, 391
Lava Rock 389, 391
Wood Chip 383, 389, 391

Noise Walls 271
Forms 275
Prefabricated Columns 273, 282
Prefabricated Wall Panels 273, 282

Object Disposal **64**

Object Preservation **64**

Object Removal **63**

Pavement Fabric **149**

Pavement Markings **517**
Acceptance 523
Glass Beads 518
Installation – General 521
Installation – Marking Tape 522
Installation – Paint 521
Non-Lane Line Paint 518
Paint 517
Preformed Pavement Marking Tape 519

Pavement Milling **81**
full-depth 83
General 81
Partial-depth 82

Pavement Removal **81**
Brick 85
full-depth 83
General 81

PCC **76**
Admixtures 74, 160, 175, 189, 217, 232, 248, 259, 271, 283, 326, 347, 395, 433, 445, 460, 491, 531
Aggregate ..73, 160, 175, 189, 217, 232, 247, 259, 271, 283, 326, 347, 395, 433, 445, 460, 490, 531
Coloring Agent 160, 176, 190, 218, 260, 272, 284
Construction 165
Construction Joints 171, 185, 269, 292, 356, 404
Contraction Joints 170, 185, 292, 356, 404
Curing Materials 162, 177, 191, 219, 234, 249, 261, 273, 285, 328, 348, 397, 435, 447, 462, 492, 532
Defective or Substandard 171, 185, 201, 214, 227, 241, 269, 281, 292, 404
Equipment 162, 178, 192, 262, 286, 349, 397
Footings 351
Form Removal 226, 268
Forms 164, 179, 193, 220, 263, 275, 287, 350, 398
Joints 227
Mix Design 162, 177, 191, 218, 233, 248, 260, 272, 284, 348, 396, 434, 446, 461, 491, 532
Mix Design for Sewer Structures 327
Opening for Use 186
Opening/Using 172, 202
Pay Factors 173
Placement 180, 195, 221, 263, 276, 288, 351, 400
Plaster Coating 324
Portland Cement 73, 159, 175, 189, 217, 231, 247, 259, 271, 283, 326, 347, 395, 433, 445, 460, 490, 531

Reinforcement 161, 164, 177, 180, 191, 194, 219, 221, 233, 261, 263, 273, 275, 285, 287, 348, 350, 396, 399, 434, 446, 461, 492, 532
Stain 160, 176, 190, 218, 260, 272, 284
Thickness 172, 186, 202, 356, 404
Water 74, 175, 189, 217, 232, 247, 259, 271, 283, 326, 347, 395, 433, 445, 460, 490, 531
Water 160

PCC Retaining Walls 259
Backfill 269

PCC Stairs 283
Backfill 293

Plant Materials 381
Collected 382
Establishment Period 386
Fertilizer 382, 387
Guy Wiring 383
Mulch – wood chip 383
Nursery-Grown 381
Peat Moss 383
Planting 385
Receiving 384
Storing 384
Transporting 384
Tree Wrap 384

Preemption Control Systems 569
Detector Cable 569
Installation 571
System 569

Public Information 587

Railings 295
Aluminum 295
Aluminum Capacity Plates 296
Aluminum Ornamental 296
Anchor Bolts 296
Bolt steel 295
Cast Iron Capacity Plates 296
Construction 297
Eyebar steel 295
Malleable Castings 295
Rivet Steel 295
Steel Ornamental 296
Steel Pipe 295
Structural steel 295

Recycled ACP 119
Asphaltic concrete pavement: 130
Base 119
Emulsified Asphalt 119

Placement 120
Processing 119
Surface 119

Recycled PCC 123
Processing 124

Revet Mattresses
Fill Material 427
Geotextile fabric 428
Wire mesh baskets 428

Rip Rap 393
Broken PCC 393
Sedum Stoloniferum Plants 393
Stone 393

Seeding 369
Application 373
Emulsified Asphalt 371
Establishment Period 372
Fertilizer 370, 373
Hydraulic 370
Irrigated Lawn and Turf 369
Mulch – hay or straw 370, 373
Mulch – hydraulic 371, 374
Non-irrigated Lawn and Turf 369
Overseeding 374
Reseeding 374
Type A 370
Type B 370

Segmental Retaining Walls 253
Cap Adhesive 254
Cap Block 256
Construction 255
Design 254
Drainable Fill Material 253
Drainage Collection Pipe 253, 256
Geotextile Filter 254
Grading 255
Leveling Pad 255
Reinforced Backfill 254, 256
Unit 253

Service Disconnects 543
Disconnect Switch Enclosure 543
Enclosure 543
Permanent Installation 546
Service Conductors 544
Temporary Installation 550
Wiring Schematics 543
Wood Post 544

Sewer Abandonment 73
Backfill 78
Backfill Compaction 78
Brick 73
Concrete Block 73
Fill Material 77
Flowable Fill 77
Mortar 73
Pipe Plug 77
Sand Gravel 73
Sewer Preparation 76

Sewer Mastic Requirement for Concrete Pipe 301

Sewer Pipe 299
Acceptance Testing 316
Aggregate Bedding 305, 312
Aggregate Gradation 305
Backfill 314
Bar Grates 306
Bore and Jack Installation 310
Collars 338
Combined Sewer Materials 299
Connections 314
Corrugated Aluminum Pipe 302, 309
Corrugated Steel Pipe 301
Cradles 338
Culvert Materials 299
Ductile Iron Pipe 302, 309
Encasements 338
Excavation 309
Fiberglass Pipe 304, 309
Flared End Sections 304
Flexible Pipe, defined 299
Flowable Fill Backfill 315
General Installation 312
Joint Filler 305
Joint Mortar 305
Joints 313
Manufacturing Facilities 308
PCC for Pipe Cradles, Encasements, and Collars 306
PCC Pipe 300, 308
Pipe Bedding 311
Pipe Couplings 304
Pipe Cradles, Encasements, and Collars 314
PVC Pipe 303, 309
PVC Pipe Joints 313
Rigid Pipe, defined 299
Sanitary Sewer Materials 299
Steel Casing 306
Steel Casing Wall Thickness 307
Steel Pipe 309
Storm Sewer Materials 299
Tee Branches 304
Video Inspection 365

Vitrified Clay Pipe 303, 309
Wye Branches 304, 314

Sewer Service Lines 68

Sheet Piling 229

Signage ..... See Signs

Signs 528
Anchors 443
Cantilever Structures 439, 536
Conduit 530
Construction 535
Fasteners 529
Fiber Optic Blank Out 527
Grounding Rods 530
Grounding Wire 530
Installation 540
LED Blank Out 527
Lighting 527
Mast Arm 454
Metal Poles 440, 449
Mounting Hardware 529
Permanent Sign Post Installation 536
Poles 439
Sign Brackets 530
Square Tubular Posts 528
Steel U-Posts 529
Temporary Sign Drums 528
Temporary Sign Post Installation 536
Test Stakes 530
Wood Poles 441, 453
Yielding Post Support 529

Slope Drains 407
Temporary 407

Slope Protection
PCC 395

Slurry Seal 157
Mix Design 157

Sodding 377
Fertilizer 377
Sod 377
Stakes 377
Watering 378

Special Structures 321
Acceptance Testing 341
Aggregate Bedding 325

Backfill 339
Bedding....329
Connections 338
Flowable Fill Backfill 341
Grout 325
Installation....329
Invert Channels....337
Mortar....324
PCC 321
PCC 325
Wye Branches....338

Sprinkler Systems 589
Installation....589
Reconnection 589
Relocation 589
Removal....589
Repair....589

Street Lights
Anchor bolts....442
Anchors 443
Bonding Clamps 479
Conduit 479
Extensions....443
Grounding Wire....478
Installation....484
Luminaire Arms 443
Luminaire Heads....478
Luminaires....455
Metal Poles 440, 449
Poles 439
Splice Boxes 479
Wood Poles 441, 453

Structures and Obstructions Removal 67

Subgrade Preparation 105

Tack Coat 91, 129

Topsoil.... 367

Traffic Signal Controllers 487
Aggregate Base 490
Conduit 489
Conflict Monitor 488
Controller....488
Controller Cabinet 488
Flasher 489
Grounding Rods 490
Grounding Wire....490
Installation....499

Installation – Pad-Mounted 495
Installation – Pole-Mounted 495
Modems 489
Switch Pack 489
System Memory Prom Module 487
Telephone Lines 489, 500
Two Channel Isolators 489

Traffic Signals
Anchor Bolts 442
Anchor Rods 443
Anchors 443
Backfill Compaction 88
Bonding Clamps 444, 479
Cables 479, 503
Communication Cables 480, 504
Conduit 444, 479
Conventional 475
Grounding Rods 443
Grounding Wire 443, 478
Grout 443
Guy Guards 444
Guy Wire 444
Installation 484
Mast Arms 439, 442, 454
Metal Poles 440, 449
Mounting Hardware 478
Optically Programmed 476
Pedestal Poles 441, 449
Pedestrian Signals 478, 484
Pedestrian Symbols 478
Pipe Handrails 443
Poles 439
Push Button Lead-in Cables 479, 504
Pushbuttons 478
Removal 87
Sealing Compound 443
Service Cables 480, 504
Span Wire 444, 455
Splice Boxes 479
Test Stakes 443
Tie Wire 444, 455
Transformer Bases 442
Truss Structures ..... See Truss Structures
Wood Poles 441, 453

Truss Structures 457
Aluminum Castings 458
Aluminum Gratings 458
Aluminum Plates 458
Aluminum Welding 465
Chord Caps 458
Conduit 459
Extruded Shapes 458
Extruded Tubes 458

Fabrication 464
Foundations 468
Grounding Rods 459
Grounding Wire....459
Hardware 459
Installation....472
Material Handling....464
Pipe Handrails....458
Post Caps 458
Sealing Compound 459
Steel Welding 467
Structural Steel 459
Test Stakes....459
Welded Materials 459
Welding Materials 459

Unsuitable Materials.... 99

Vehicle Detectors.... 553
Amplifiers 553
Conduit 554
Detector Lead-in Cable....553
Detectors – Magnetic....553
Loop Detector Installation 557
Loop Detector Wire....553
Radar/Microwave 553
Sealant 553

Vehicle Detectors - Modular Video 559
Extension Module 562
Maintenance 563
Miscellaneous Hardware....563
Power Cabling....563
Processor 561
Support 563
System Installation....566
System Training....566
Transmission Cable....563
Video Camera....560
Warranty 563

Vehicle Detectors – Wide Area Video
Image Sensors 574
Installation....584
Machine Vision Processor....576
Maintenance 581
Miscellaneous Hardware....581
Software....580
Supervisor Computer 580
Support 581
Training....585
Video Camera....573
Video Isolation Amplifier....580
Warranty 581

Water Services 359
Backfill 362
Copper pipe 359
Curb Boxes 361
Curb Stops 361
Service Pipe Replacement 361
Transition Fittings 362
Water Main Taps 359, 361
Water Meter Manholes 360
Water Meters 360

Work
Abbreviations 1, 2
Acceptance 60
Acronyms 1, 2
Adjacent Land 36
Allowable Deviations 31
Alteration of Plans or Character of Work 27
Altered Quantities 55
Alternates 21
Authority of the Engineer 31
Award of Contract 25
Barricades 42
Bond 26
Cancellation of Award 25
Changes 56
Completion of the Work 47
Conditions 21
Contractor Methods and Equipment 49
Cooperation between Contractors 33
Cooperation of the Contractor 32
Coordination of the Contract Documents 32
Damage Claims 43
Debris 28
Default Contracts 51
Definition of Terms 3
Delivery of Proposals 22
Differing Site Conditions 56
Discarded Materials 28
Disqualification of Bidder 23
Eliminated Items 58
Execution of Contract 26
Explosives 45
Extra Work 27, 56
Failure to Execute Contract 26
Final Clean Up 29
Force Account Work 56
Guarantee 52
Hazardous Material 46
Heavy Equipment 35
Incentive 53
Inspection 34
Inspection – Final 36
Insurance 43
Intent of Contract 27

Labor 61
Labor Laws 61
Licenses 41
Limitations 21
Liquidated Damages 50
Maintenance of Detours 28
Material Guaranty 23
Materials 37
Materials – City Furnished 39
Materials – Unacceptable 38
Measurement of Quantities 55
Non-Salvaged Materials 68
Notice to Bidders 26
Obstructions 28
Patents 41
Payment 55
Permits 41
Plans 31
Preparation of Proposals 21
Progress Payments 58
Project Representative 34
Proposal Forms 19
Proposal Guaranty 22
Prosecution of the Work 48
Qualification of Bidders 19
Quantities 20
References 1, 2
Return of Proposal Guaranties 25
Rights In and Use of Materials 29
Rubbish 28
Salvaged Materials 68
Stored Materials 59
Structures 28
Subletting 47
Surplus Materials 28
Surveying 34
Taxes 41
Ties 21
Unacceptable Work and Materials 35
Unit Price 21
Utilities, Cooperation with 32
Withdrawal of Proposals 22
Working Days 47
Working Drawings 31