SECTION 03200

STEEL REINFORCEMENT

PART 1 - GENERAL

1.01 DESCRIPTION

The Contractor shall furnish, fabricate, and place all concrete reinforcement steel, welded wire fabric, couplers, and concrete inserts for use in reinforced concrete construction and shall perform all appurtenant work, including all the wires, clips, supports, chairs, spacers, and other accessories, all in accordance with the Contract Documents. The Contract Documents shall take precedence over these specifications.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

The publications listed below form part of this specification to the extent referenced and are referred to in the text by the basic designation only. Reference shall be made to the latest edition of said standards unless otherwise called for.

A. Codes: All codes, as referenced herein and specified in Section 01015.

B. Commercial Standards:

ACI 301	Structural Concrete for Buildings
ACI 315	Details and Detailing of Concrete Reinforcement
ACI 318	Building Code Requirements for Reinforced Concrete
CRSI MSP-1	Concrete Reinforcing Steel Institute Manual of Standard Practice
WRI	Manual of Standard Practice for Welded Wire Fabric
AWA D1.4	Structural Welding Code – Reinforcing Steel
ASTM A82	Specification for Welded Steel Wire, Plain, for Concrete Reinforcement
ASTM A185	Specification for Welded Steel Wire Fabric, Plain, for Concrete Reinforcement
ASTM A615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A706	Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A775	Specification for Epoxy-Coated Reinforcing Steel Bars

AWS D1.4 Structural Welding Code for Reinforcing Steel

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300 – Shop Drawings and Submittals

B. Section 01410 – Testing Laboratory Services

C. Section 03300 – Cast-In-Place Concrete

D. Section 03315 – Grout

1.04 CONTRACTOR SUBMITTALS

A. The Contractor shall furnish reinforcement placing drawings, shop bending diagrams, placing lists, and drawings of all reinforcement steel prior to fabrication in accordance with the requirements of Section 01300.

B. Details of the concrete reinforcement steel and concrete inserts shall be submitted by the Contractor at the earliest possible date after receipt by the Contractor of the Notice to Proceed. Said details of reinforcement steel for fabrication and erection shall conform to ACI 315 and the requirements specified and shown. The shop bending diagrams shall show the actual lengths of bars, to the nearest inch measured to the intersection of the extensions (tangents for bars of circular cross section) of the outside surface. The shop drawings shall include bar placement diagrams that clearly indicate the dimensions of each bar splice.

C. Contractor shall submit mill tests reports for each heat of reinforcement steel.

D. Where mechanical couplers are required or permitted to be used to splice reinforcement steel, the Contractor shall submit manufacturer's literature which contains instructions and recommendations for installation for each type of coupler used; certified test reports which verify the load capacity of each type and size of coupler used; and shop drawings which show the location of each coupler with details of how they are to be installed in the formwork.

E. If reinforcement steel is spliced by welding at any location, the Contractor shall submit mill test reports which shall contain the information necessary for the determination of the carbon equivalent as specified in AWS D1.4. The Contractor shall submit a written welding procedure for each type of weld for each size of bar which is to be spliced by welding; merely a statement that AWS procedures will be followed is not acceptable. Welding of reinforcing bars shall be done only where specifically detailed on the plans or when permitted by the Engineer.

F. Contractor shall submit all reinforcing for a given structure in a single submittal at one time. Partial reinforcing submittals may be returned to the Contractor rejected for incompleteness.

1.05 QUALITY ASSURANCE

A. If requested by the Engineer, the Contractor shall provide samples from each heat of reinforcement steel delivered in a quality adequate for testing. Costs of tests will be paid by the Contractor.

B. If reinforcement steel is spliced by welding at any location, the Contractor shall submit certifications of procedure qualifications for each welding procedure used and certification of welder qualifications, for each welding procedure, and for each welder performing the work. Such qualifications shall be as specified in AWS D1.4.

C. If requested by the Engineer, the Contractor shall provide samples of each type of welded splice used in the work in a quantity and of dimensions adequate for testing. At the discretion of the Engineer, radiographic testing of direct butt welded splices will be performed. The Contractor shall provide assistance necessary to facilitate testing. The Contractor shall repair any weld which fails to meet the requirements of AWS D1.4. The costs of testing will be paid by the Contractor.

D. Inspection: All work hereunder shall be subject to continuous inspection by a Special Inspector approved by the District and approved by the local Building Official having jurisdiction. Special Inspection shall be performed in accordance with the latest edition of the Uniform Building Code. The Special Inspector shall work under the direct supervision of the Contractor. All costs of such inspection shall be borne by the Contractor and shall be included in the price bid for completion of the work.

E. The Special Inspector shall observe the following work for conformance with the design drawings and specifications:

1. Placing of all reinforcing steel in concrete requiring special inspection

2. Welding of all reinforcing steel

PART 2 - PRODUCTS

2.01 MATERIAL REQUIREMENTS

Materials specified in this Section which may remain or leave residues on or within the concrete shall be classified as acceptable for potable water use within 30 days of application or use by the Environmental Protection Agency.

2.02 REINFORCEMENT STEEL

A. Reinforcement steel for all cast-in-place reinforced concrete construction shall conform to the following requirements:

1. Bar reinforcement shall conform to the requirements of ASTM A615 for Grade 60 Billet Steel Reinforcement or as otherwise shown.

2. Welded wire fabric reinforcement shall conform to the requirements of ASTM A185 and the details shown; provided, that welded wire fabric with longitudinal wire of WR size wire and smaller shall be either furnished in flat sheets or in

rolls with a core diameter of not less than 10 inches; and provided further, that welded wire fabric with longitudinal wires larger than W4 size shall be furnished in flat sheets only.

3. Spiral reinforcement shall be cold-drawn steel wire conforming to the requirements of ASTM A82.

4. Bar reinforcement used in welded connections shall conform to the requirements of ASTM A706.

B. Accessories

1. Accessories shall include all necessary chairs, slab bolsters, concrete blocks, tie wires, dips, supports, spacers, and other devices to position reinforcement during concrete placement. All bar supports shall meet the requirements of the CRSI Manual Standard Practice including special requirements for supporting epoxy coated reinforcing bars. Wire bar supports shall be CRSI Class 1 for maximum protection with a 1/8-inch minimum thickness of plastic coating which extends at least ½-inch from the concrete surface. Plastic shall be gray in color.

2. Concrete blocks (dobies), used to support and position reinforcement steel, shall have the same or higher compressive strength as specified for the concrete in which it is located. Wire ties shall be embedded in concrete block bar supports.

C. Epoxy coating for reinforcing and accessories, where specified or shown, shall conform to ASTM A775.

D. Drilling of reinforcing bars in place of cast-in-place hooks and anchors will not be permitted unless previously approved by the Engineer in writing.

2.03 MECHANICAL COUPLERS

A. Mechanical couplers shall be provided where shown and where approved by the Engineer. The couplers shall develop a tensile strength which exceeds 125 percent of the yield strength of the reinforcement bars being spliced at each splice.

B. Where the type of coupler used is composed of more than one component, all components required for a complete splice shall be supplied. This shall apply to all mechanical splices including those splices intended for future connections.

C. The reinforcement steel and coupler used shall be compatible for obtaining the required strength of the connection. Straight threaded type couplers shall require the use of the next larger size reinforcing bar or shall be used with reinforcing bars with specially forged ends which provide upset threads which do not decrease the basic cross section of the bar.

D. Couplers shall be Lenton Form Saver as manufactured by Erico Products; Dowel Bar Splicer System as manufactured by Richmond Screw Anchor Company; or equal.

2.04 WELDED SPLICES

A. Welded splices shall be provided where shown and where approved by the Engineer. All welded splices of reinforcement steel shall develop a tensile strength which exceeds 125 percent of the yield strength of the reinforcement bars which are connected.

B. All materials required to conform the welded splices to the requirements of AWS D1.4 shall be provided.

2.05 EPOXY GROUT

Epoxy for grouting reinforcing bars shall be specifically formulated for such application, for the moisture condition, application temperature, and orientation of the hole to be filled. Epoxy grout shall meet the requirements of Section 03315.

PART 3 - EXECUTION

3.01 GENERAL

All reinforcement steel, welded wire fabric, couplers, and other appurtenances shall be fabricated, and placed in accordance with the requirements of the Building Code and the supplementary requirements specified herein.

3.02 FABRICATION

A. General

1. Reinforcement steel shall be accurately formed to the dimensions and shapes shown, and the fabricating details shall be prepared in accordance with ACI 315 and ACI 318, except as modified by the Drawings. Stirrups and tie bars shall be bent around a pin having diameter not less than 1-1/2-inch for No. 3 bars, 2-inch for No. 4 bars, and 2-1/2-inch for No. 5 bars. Bends for other bars shall be made around a pin having a diameter not less than 6 times the bar diameter, except for bars larger than 1 inch, in which case the bends shall be made around a pin of 8 bar diameters. Bar bends shall be made cold.

2. The Contractor shall fabricate reinforcement bars for structures in accordance with bending diagrams, placing lists, and placing drawings. Said drawings, diagrams, and lists shall be prepared by the Contractor as specified under Section 01300.

B. Fabricating Tolerances: Bars used for concrete reinforcement shall meet the following requirements for fabricating tolerances:

1. Sheared length: ± 1-inch

2. Depth of truss bars: + 0, -1/2-inch

3. Stirrups, ties, and spirals: ± ½-inch

4. All other bends: ± 1-inch

3.03 PLACING

A. Reinforcement steel shall be accurately positioned as shown, and shall be supported and wired together to prevent displacement, using annealed iron wire ties or suitable clips at intersections. All reinforcement steel shall be supported by concrete, plastic or metal supports, spacers or metal hangers which are strong and rigid enough to prevent any displacement of the reinforcement steel. Where concrete is to be placed on the ground, supporting concrete blocks (or dobies) shall be used, in sufficient numbers to support the bars without settlement, but in no case shall such support be continuous. All concrete blocks used to support reinforcement steel shall be tied to the steel with wire ties which are embedded in the blocks. For concrete over formwork, the Contractor shall furnish concrete, metal, plastic, or other acceptable bar chairs and spacers.

B. Reinforcing shall be accurately positioned around pipe opening to conform to the required tolerances. Placement of reinforcing mats without required pipe openings followed by field cutting of mat to clear pipe flange shall not be permitted.

C. Limitations on the use of bar support materials shall be as follows:

1. Concrete Dobies: permitted at all locations except where architectural finish is required.

2. Wire Bar Supports: permitted only at slabs over dry areas, interior dry wall surfaces, and exterior wall surfaces.

3. Plastic Bar Supports: permitted at all locations except on grade.

D. Tie wires shall be bent away from the forms in order to provide the specified concrete coverage.

E. Bars additional to those shown which may be found necessary or desirable by the Contractor for the purpose of securing reinforcement in position shall be provided by the Contractor at his own expense.

F. Unless otherwise specified, reinforcement placing tolerances shall be within the limits specified in Section 7.5 of ACI 318 except where in conflict with the requirements of the Building Code.

G. Bars may be moved as necessary to avoid interference with other reinforcement steel, conduits, or embedded items. If bars are moved more than one bar diameter, or enough to exceed the above tolerances, the resulting arrangement of bars shall be as acceptable to the Engineer.

H. Welded wire fabric reinforcement placed over horizontal forms shall be supported on slab bolsters. Slab bolsters shall be spaced not more than 30 inches on centers, shall extend continuously across the entire width of the reinforcement mat, and shall support the reinforcement mat in the plane shown.

I. Welded wire fabric placed over the ground shall be supported on wired concrete blocks (dobies) spaced not more than 3 feet on centers in any direction. The construction

practice of placing welded wire fabric on the ground and hooking into place in the freshly placed concrete shall not be used.

J. Epoxy coated reinforcing bars shall be stored, transported, and placed in such a manner as to avoid chipping of the epoxy coating. Non-abrasive slings made of nylon and similar materials shall be used. Specially coated bar supports shall be used. All chips or cracks in the epoxy coating shall be repaired with a compatible epoxy repair material prior to placing concrete.

K. Accessories supporting reinforcing bars shall be spaced such that there is no deflection of the accessory form the weight of the supported bars. When used to space the reinforcing bars from wall forms, the forms and bars shall be located so that there is no deflection of the accessory when the forms are tightened into position.

3.04 SPACING OF BARS

A. The clear distance between parallel bars (except in columns and between multiple layers of bars in beams) shall be not less than the nominal diameter of the bars nor less than 1-1/3 times the maximum size of the coarse aggregate, nor less than one inch.

B. Where reinforcement in beams or girders is placed in 2 or more layers, the clear distance between layers shall be not less than one inch.

C. In columns, the clear distance between longitudinal bars shall be not less than 1-1/2 times the bar diameter, nor less than 1-1/2 times the maximum size of the coarse aggregate, nor less than 1-1/2 inches.

D. The clear distance between bars shall also apply to the distance between a contact splice and adjacent splices or bars.

3.05 SPLICES

A. General:

1. Reinforcement bar splices shall only be used at locations shown. When it is necessary to splice reinforcement at points other than where shown, the character of the splice shall be as acceptable to the Engineer.

2. Unless otherwise indicates, dowels shall match the size and spacing of the spliced bar.

B. Splices of Reinforcement

1. Unless otherwise shown, the length of lap for reinforcement bars shall be in accordance with ACI 318-95, Section 12.15.1 for a Class B, category 3 splice.

2. Laps of welded wire fabric shall be in accordance with the ACI 318. Adjoining sheets shall be securely tied together with No. 14 tie wire, one tie for each 2 running feet. Wires shall be staggered and tied in such a manner that they cannot slip.

3. Splices in column spiral reinforcement, when necessary, shall be made by welding or by a lap of 1-1/2 turns.

C. Bending or Straightening

1. Reinforcement shall not be straightened or rebent in a manner which will injure the material. Bars with kinks or bends not shown shall not be used. All bar bends shall be made cold, unless otherwise permitted by the Engineer. No bars partially embedded in concrete shall be field-bent except as shown or specifically permitted by the Engineer.

D. Couplers which are located at a joint face shall be a type which can be set either flush or recessed from the face as shown. The couplers shall be sealed during concrete placement to completely eliminate concrete or cement paste from entering. Couplers intended for future connections shall be recessed a minimum of 1/2-inch from the concrete surface. After the concrete is placed, the coupler shall be plugged with plastic plugs which have an O-ring seal and the recess filled with sealant to prevent any contact with water or other corrosive materials. Threaded couplers shall be plugged.

E. Unless noted otherwise, mechanical coupler spacing and capacity shall match the spacing and capacity of the reinforcing shown for the adjacent section.

3.06 CLEANING AND PROTECTION

A. Reinforcement steel shall at all times be protected from conditions conducive to corrosion until concrete is placed around it.

B. The surfaces of all reinforcement steel and other metalwork to be in contact with concrete shall be thoroughly cleaned of all dirt, grease, loose scale and rust, grout, mortar and other foreign substances immediately before the concrete is placed. Where there is delay in depositing concrete, reinforcement shall be re-inspected and, if necessary re-cleaned.

3.07 EMBEDMENT OF DRILLED REINFORCING STEEL DOWELS

A. Hole Preparation

1. The hole diameter shall be as recommended by the epoxy manufacturer, but shall be no larger than 0.25 inch greater than the diameter of the outer surface of the reinforcing bar deformations.

2. The depth of the hole shall be as recommended by the epoxy manufacturer to fully develop the bar but shall not be less than 12 bar diameters, unless noted otherwise.

3. The hole shall be drilled by methods which do not interfere with the proper bonding of epoxy.

4. Existing reinforcing steel in the vicinity of proposed holes shall be located prior to drilling. The location of holes to be drilled shall be adjusted to avoid drilling through or nicking any existing reinforcing bars.

5. The hole shall be blown clean with clean, dry compressed air to remove all dust and loose particles.

6. Epoxy shall be injected into the hole through a tube placed to the bottom of the hole. The tube shall be withdrawn as epoxy is placed but kept immersed to prevent formation of air pockets. The hole shall be filled to a depth that insures that excess material will be expelled from the hole during dowel placement.

7. Dowels shall be twisted during insertion into the partially filled hole so as to guarantee full wetting of the bar surface with epoxy. The bar shall be inserted slowly enough to avoid developing air pockets.

8. Drilled reinforcing dowels shall only be used where specifically detailed on the Drawings or when permitted by the Engineer in writing.

END OF SECTION

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 DESCRIPTION

A. The Contractor shall furnish all materials for concrete in accordance with the provisions of this Section and shall form, mix, place, cure, repair, finish, and do all other Work as required to produce finished concrete, in accordance with the requirements of the Contract Documents.

B. The following types of concrete shall be covered in this Section:

1. Structural Concrete: Concrete to be used in all cases except where noted otherwise in the Contract Documents. Concrete to be used for curbs, gutters, catch basins, sidewalks, pavements, thrust blocks, valve anchor blocks, fence and guard post footings, and all other concrete unless otherwise shown.

2. Lean Concrete: Concrete to be used for underground duct bank encasement, pipe trench cut-off walls, non-structural pipe encasement or cradles where the preceding items are detailed on the Drawings as unreinforced. Concrete to be used as protective cover for dowels intended for future connection. Concrete backfill around soldier piles placed above the bottom of the excavation.

C. The term “hydraulic structure” used in these specifications shall refer to environmental engineering concrete structures for the containment, treatment, or transmission of water, wastewater, or other fluids.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

The publications listed below form part of this specification to the extent referenced and are referred to in the text by the basic designation only. Reference shall be made to the latest edition of said standards unless otherwise called for.

A. Federal Specifications:

UU-B-790A (1) (2)	Building Paper, Vegetable Fiber (Kraft, Waterproofed, Water Repellant and Fire Resistant)

B. Commercial Standards:

ACI 117	Standard Tolerances for Concrete Construction and Materials
ACI 214	Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 301	Specifications for Structural Concrete for Buildings

ACI 309	Consolidation of Concrete
ACI 315	Details and Detailing of Concrete Reinforcement
ACI 318	Building Code Requirements for Reinforced Concrete
ASTM C31	Practices for Making and Curing Concrete Test Specimens in the Field
ASTM C33	Specification for Concrete Aggregates
ASTM C39	Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C94	Specification for Ready-Mixed Concrete
ASTM C136	Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C143	Test Method for Slump of Hydraulic Cement Concrete
ASTM C150	Specification for Portland Cement
ASTM C156	Test Methods for Water Retention by Concrete Curing Materials
ASTM C157	Test Method for Length Change of Hardened Hydraulic Cement Mortar and Concrete
ASTM C192	Method of Making and Curing Concrete Test Specimens in the Laboratory
ASTM C260	Specification for Air-Entraining Admixtures for Concrete
ASTM C309	Specifications for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494	Specification for Chemical Admixtures for Concrete
ASTM C920	Specifications for Elastomeric Joint Sealant
ASTM C1077	Practice for Laboratories Testing Concrete and Concrete Aggregates for use in Construction & Criteria for Laboratory Evaluation
ASTM D175	Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non- Extruding and Resilient Bituminous Types)
ASTM D2419	Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM E119	Method for Fire Tests of Building Construction and Materials

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300 – Contractor Submittals

B. Section 01410 – Testing Laboratory Services

C. Section 03200 – Steel Reinforcement

1.04 SUBMITTALS

A. Mix Designs: Prior to beginning the Work and within 14 days of the notice to proceed, the Contractor shall submit concrete mix designs in accordance with Section 01300 which shall show the proportions and gradations of all materials proposed for each class and type of concrete specified herein.

The Contractor shall submit mix designs from a minimum of two qualified batch plants for review.

The mix designs shall be checked by an independent testing laboratory acceptable to the District. All costs related to such checking shall be borne by the Contractor. Since laboratory trial batches require 35 calendar days to complete, the Contractor may consider testing more than one mix design for each class of concrete.

B. Delivery Tickets: The Contractor shall furnish delivery tickets at the time of delivery for each load of concrete. Each ticket shall show the state certified equipment used for measuring and the total quantities, by weight, or cement, sand, each class of aggregate, admixtures, and the amounts of water in the aggregate added at the batching plant, and the amount allowed to be added at the site for the specific design mix. In addition, each ticket shall state the mix number, total yield in cubic yards, and the time of day, to the nearest minute, corresponding to the times when the batch was dispatched, when it left the plant, when it arrived at the site, when unloading began, and when unloading was finished.

C. Provide the following submittals in accordance with ACI 301:

1. Mill tests for cement

2. Admixture certification. Chloride ion content must be included.

3. Aggregate gradation and certification

4. Materials and methods for curing

5. Results of 7, 14, and 28-day compressive tests done on trial batches

6. Results of shrinkage drying tests

1.05 QUALITY ASSURANCE

A. General:

1. Tests on component materials and for compressive strength and shrinkage of concrete will be performed as specified herein. Tests for determining slump will be in accordance with the requirements of ASTM C143.

2. The cost of all laboratory tests on cement, aggregates, and concrete will be borne by Contractor. However, the Contractor shall be charged for the cost of any additional tests and investigation on Work performed which does not meet the specifications. The laboratory must meet or exceed the requirements of ASTM C1077.

3. Concrete for testing shall be supplied by the Contractor at no cost to the testing laboratory and the Contractor shall provide assistance in obtaining samples, and disposal and cleanup of excess material.

B. Compression Tests:

1. Compression test specimens will be taken during construction from the first placement of each class of concrete and at intervals in accordance with ACI 301 to insure continued compliance with these specifications. Each set of test specimens will be a minimum of 5 cylinders.

2. Compression test specimens for concrete shall be made in accordance with Section 9.2 of ASTM C31. Specimens shall be 6-inch diameter by 12-inch high cylinders.

3. Compression tests shall be performed in accordance with ASTM C39. One test cylinder will be tested at 7 days, one test cylinder will be tested at 14 days and one test cylinder will be tested at 28 days. The remaining 2 cylinders will be held to verify test results, if needed.

C. Evaluation and Acceptance of Concrete:

1. Evaluation and acceptance of the compressive strength of concrete shall be according to the requirements of ACI 318, Chapter 5 “Concrete Quality,” and as specified herein.

2. A statistical analysis of compression test results will be performed according to the requirements of ACI 214. The standard deviation of the test results shall not exceed 640 psi, when ordered at equivalent water content as estimated by slump.

3. If any concrete fails to meet these requirements, immediate corrective action shall be taken to increase the compressive strength for all subsequent batches of the type of concrete affected.

4. When the standard deviation of the test results exceeds 640 psi, the average strength for which the mix is designed shall be increased by an amount necessary to satisfy the statistical requirement that the probability of any test being more than 500 psi below or the average of any 3 consecutive tests being below the specified compressive strength is 1 in 100. The required average strength shall be calculated by Criterion No. 3 of ACI 214 using the actual standard of deviation.

5. All concrete which fails to meet the ACI requirements and these specifications, is subject to removal and replacement at the cost of the Contractor.

D. Shrinkage Tests:

1. Drying shrinkage tests will be made for the trial batch specified in the Paragraph in Part 2 entitled, "Trial Batch and Laboratory Tests," the first placement of each class of concrete, and during construction to insure continued compliance with these Specifications.

2. Drying shrinkage specimens shall be 4-inch by 4-inch by 11-inch prisms with an effective gage length of 10 inches, fabricated, cured, dried and measured in accordance with ASTM C157 modified as follows: specimens shall be removed from molds at an age of 23 ± 1 hours after trial batching, shall be placed immediately in water at 70 degrees F ±3 degrees F for at least 30 minutes, and shall be measured within 30 minutes thereafter to determine original length and then submerged in saturated lime water at 73 degrees F ±3 degrees F. Measurement to determine expansion expressed as a percentage of original length shall be made at age 7 days. This length at age 7 days shall be the base length for drying shrinkage calculations ("0" days drying age). Specimens then shall be stored immediately in a humidity control room maintained at 73 degrees F ±3 degrees F and 50 percent ±4 percent relative humidity for the remainder of the test. Measurements to determine shrinkage expressed as percentage of base length shall be made and reported separately for 7, 14, 21, and 28 days of drying after 7 days of moist curing.

3. The drying shrinkage deformation of each specimen shall be computed as the difference between the base length (at "0" days drying age) and the length after at each test age. The average drying shrinkage deformation of the specimens shall be computed to the nearest 0.0001 inch at each test age. If the drying shrinkage of any specimen departs from the average of the test age by more than 0.0004-inch, the results obtained from the specimen shall be disregarded. Results of the shrinkage test shall be reported to the nearest 0.001 percent of shrinkage. Compression test specimens shall be taken in each case from the same concrete used for preparing drying shrinkage specimens. These tests shall be considered a part of the normal compression tests for the projects. Allowable shrinkage limitations shall be as specified in Part 2, herein.

E. Construction Tolerances: The Contractor shall set and maintain concrete forms and perform finishing operations so as to ensure that the completed Work is within the tolerances specified herein. Surface defects and irregularities are defined as finishes and are to be distinguished from tolerances. Tolerance is the specified permissible variation from lines, grades, or dimensions shown. Where tolerances are not stated in the specifications, permissible deviations will be in accordance with ACI 117.

1. The following construction tolerances are hereby established and apply to finished walls and slab unless otherwise shown:

Item	Tolerance

Item	Tolerance
Variation of the constructed linear outline from the established position in plan.	In 10 feet: ¼-inch In 20 feet or more: ½-inch
Variation from the level or from the grades shown.	In 10 feet: ¼-inch In 20 feet or more: ½-inch
Variation from the plumb.	In 10 feet: ¼-inch In 20 feet or more: ½-inch
Variation in thickness of slabs and walls.	Minus ¼-inch Plus ½-inch
Variation in the locations and sizes of slabs and wall openings.	Plus or minus ¼-inch

PART 2 - MATERIALS

2.01 CONCRETE MATERIALS

A. General:

1. All materials specified herein shall be classified as acceptable for potable water use within 30 days of application by the Environmental Protection Agency.

2. Materials shall be delivered, stored, and handled so as to prevent damage by water or breakage. Only one brand of cement shall be used. Cement reclaimed from cleaning bags or leaking containers shall not be used. All cement shall be used in the sequence of receipt of shipments.

B. All materials furnished for the Work shall comply with the requirements of Sections 201, 203, and 204 of ACI 301, as applicable.

C. Storage of materials shall conform to the requirements of Section 205 of ACI 301.

D. Materials for concrete shall conform to the following requirements:

1. Cement shall be standard brand portland cement conforming to ASTM C150 for Type II/V, including Table 2 optional requirements. A minimum of 85 percent of cement by weight shall pass a 325 screen. A single brand of cement shall be

used throughout the Work, and prior to its use, the brand shall be acceptable to the Engineer. The cement shall be suitably protected from exposure to moisture until used. Cement that has become lumpy shall not be used. Sacked cement shall be stored in such a manner so as to permit access for inspection and sampling. Certified mill test reports, including fineness, for each shipment of cement to be used shall be submitted to the Engineer if requested regarding compliance with these Specifications.

2. Flyash is not permitted.

3. Water for mixing and curing shall be potable, clean, and free from objectionable quantities for silty organic matter, alkali, salts, and other impurities. The water shall be considered potable, for the purpose of this Section only, if it meets the requirements the local governmental agencies. Agricultural water with high total dissolved solids (over 1,000 mg/l TDS) shall not be used.

4. Aggregates shall be obtained from pits acceptable to the Engineer, shall be non-reactive, and shall conform to ASTM C33. Maximum size of coarse aggregate shall be as specified herein. Lightweight sand for fine aggregate will not be permitted.

   a. Coarse aggregates shall consist of clean, hard, durable gravel, crushed gravel, crushed rock or a combination thereof. The coarse aggregates shall be prepared and handled in two or more size groups for combined aggregates with a maximum size greater than ¾-inch. When the aggregates are proportioned for each batch of concrete the two size groups shall be combined. See the Paragraph in Part 2 entitled, “Trial Batch and Laboratory Tests” for the use of the size groups.

   b. Fine aggregates shall be natural sand or a combination of natural and manufactured sand that are hard and durable. When tested in accordance with ASTM D2419, the sand equivalency shall not be less than 75 percent for an average of three samples and no less than 70 percent for an individual test. Gradation of fine aggregates shall conform to ASTM C33. The fineness modulus of sand used shall not be over 3.00.

   c. Combined aggregates shall be well graded from coarse to fine and shall be uniformly graded between screen sizes to produce concrete that has optimum workability and consolidation characteristics. Where a trial batch is required for a mix design, the final combined aggregate gradations will be established during the trial batch process.

   d. When tested in accordance with ASTM C33, the ratio of silica released to reduction in alkalinity shall not exceed 1.0.

   e. When tested in accordance with ASTM C33, the fine aggregate shall produce a color in the supernatant liquid no darker than the reference standard color solution.

f. When tested in accordance with ASTM C33, the loss of weight of coarse aggregate shall not exceed 10 percent after 100 revolutions or 45 percent after 500 revolutions.

g. When tested in accordance with ASTM C33, the loss resulting after five cycles shall not exceed 10 percent for fine or coarse aggregate when using sodium sulfate.

5. Admixtures: All admixtures shall be compatible and by a single manufacturer capable of providing qualified field service representation. Admixtures shall be used in accordance with manufacturer's recommendations. If the use of an admixture is producing an inferior end result, the Contractor shall discontinue use of the admixture. Admixtures shall not contain thiocyanates nor more than 0.05 percent chloride ion, and shall be non-toxic after 30 days.

a. Air-entraining agent shall meet the requirements of ASTM C260. Sufficient air-entraining agent shall be used to provide a total air content of 2 to 4 percent. The Engineer reserves the right, at any time, to sample and test the air-entraining agency received on the job by the Contractor. The air-entraining agent shall be added to the batch in a portion of the mixing water. The solution shall be batched by means of a mechanical batcher capable of accurate measurement. Air content shall be tested at the point of placement. Air-entraining agency shall be Micro-Air by Master Builders; Daravair by W.R. Grace; Sika AEA-15 by Sika Corporation; or equal.

b. Set controlling and water reducing admixtures: Admixtures may be added to the Contractor's option to control the set, effect water reduction, and increase workability. The addition of an admixture shall be at the Contractor's expense. The use of an admixture shall be subject to acceptance by the Engineer. Concrete containing an admixture shall be first placed at a location determined by the Engineer. Admixtures specified herein shall conform to the requirements of ASTM C494. The required quantity of cement shall be used in the mix regardless of whether or not an admixture is used.

1) Concrete shall contain more than one water reducing admixture. Concrete containing an admixture shall be first placed at a location determined by the Engineer.

2) Set controlling admixture shall be either with or without water-reducing properties. Where the air temperature at the time of placement is expected to be consistently over 80 degrees F, a set retarding admixture such as Plastocrete by Sika Corporation; Pozzolith 300R by Master Builders; Daratard by W.R. Grace; or equal shall be used. Where the air temperature at the time of placement is expected to be consistently under 40 degrees F, a non-corrosive set accelerating admixture such as Plastocrete 161FL by Sika Corporation; Pozzutec 20 by Master Builders; Daraset by W.R.Grace; or equal shall be used.

3) Normal range water reducer shall conform to ASTM C494, Type A. WRDA 79 by W.R. Grade; Pozzolith 322-N by Master Builders; Plastocrete 161 by Sika Corporation; or equal. The quantity of admixture used sand the method of mixing shall be in accordance with the Manufacturer's instructions and recommendations.

4) High range water reducer shall conform to ASTM C494, Type F or G. Duracem 100 or WDRA 19 by W.R. Grace; Sikament FF or Sikament 86 by Sika Corporation; Rheobuild 1000 or Rheobuild 716 by Master Builders; or equal. High range water reducer shall be added to the concrete after all other ingredients have been mixed and initial slump has been verified. No more than 14 ounces of water reducer per sack of cement shall be used. Water reducer shall be considered as part of the mixing water when calculating water cement ratio.

5) If the high range water reducer is added to the concrete at the job site, if may be used in conjunction with the same water reducer added at the batch plant. Concrete shall have a slump of 3 inches ± ½-inch prior to adding the high range water reducing admixture at the job site. The high range water reducing admixture shall be accurately measured and pressure injected into the mixer as a single dose by an experienced technician. A standby system shall be provided and tested prior to each day's operation of the job site system.

6) Concrete shall be mixed at mixing speed for a minimum of 30 mixer revolutions after the addition of the high range water reducer.

2.02 CURING MATERIALS

A. Materials for curing concrete as specified herein shall conform to the following requirements and ASTM C309:

1. All curing compounds shall be white pigmented and resin based. Sodium silicate compounds shall not be allowed. Concrete curing compound shall be Kurez by Euclid Chemical Company; MB-429 as manufactured by Master Builders; L&M Cure R; or equal. Water based resin curing compounds shall be used only where local air quality regulations prohibit the use of a solvent based compound. Water based curing compounds shall be Aqua-Cure by Euclid Chemical Company; Masterkure-W by Master Builders; L&M Cure R-2; or equal.

2. Polyethylene sheet for use as concrete curing blanket shall be white, and shall have a nominal thickness of 6 mils. The loss of moisture when determined in accordance with the requirements of ASTM C156 shall not exceed 0.055 grams per square centimeter of surface.

3. Polyethylene-coated waterproof paper sheeting for use as concrete curing blanket shall consist of white polyethylene sheeting free of visible defects, uniform in

appearance, having a nominal thickness of 2 mils and permanently bonded to waterproof paper conforming to the requirements of Federal Specification UU-B-790A (1) (2). The loss of moisture, when determined in accordance with the requirements of ASTM C156, shall not exceed 0.055 gram per square centimeter of surface.

4. Polyethylene-coated burlap for use as concrete curing blanket shall be 4-mil thick, white opaque polyethylene film impregnated or extruded into one side of the burlap. Burlap shall weigh not less than 9 ounces per square yard. The loss of moisture, when determined in accordance with the requirements of ASTM C156, shall not exceed 0.055 grams per square centimeter of surface.

5. Curing mats for use in Curing Method 6 as specified herein, shall be heavy shag rugs or carpets or cotton mats quilted at 4 inches on center. Curing mats shall weigh a minimum of 12 ounces per square yard when dry.

6. Evaporation retardant shall be a material such as Colifilm as manufactured by Master Builders; Eucobar as manufactured by Euclid Chemical Company; E-CON as manufactured by L&M Consturction Chemicals, Inc.; or equal.

2.03 NON-WATERSTOP JOINT MATERIAL

A. Materials for non-waterstop joints in concrete shall conform to the following requirements:

1. Preformed joint filler shall be a non-extruding, resilient, bituminous type conforming to the requirements of ASTM D1751.

2. Elastomeric joint sealer shall conform to ASTM C920, Type S, Grade NSA, Class 25, and shall be polyurethane-based. The sealant shall be formulated for exterior use and exposure to ultra-violet rays.

3. Mastic joint sealer shall be a material that does not contain evaporating solvents; that will tenaciously adhere to concrete surfaces; that will remain permanently resilient and pliable; that will not be affected by continuous presence of water and will not in any water contaminate potable water; and that will effectively seal the joints against moisture infiltration even when the joints are subject to movement due to expansion and contraction. The sealer shall be composed of special asphalts or similar materials blended with lubricating and plasticizing agents to form a tough, durable mastic substance containing no volatile oils or lubricants and shall be capable of meeting the test requirements set forth hereinafter, if testing is required by the Engineer.

2.04 MISCELLANEOUS MATERIALS

A. Damp-proofing agent shall be an asphalt emulsion, such as Hydrocide 600 by Sonneborn; Damp-proofing Asphalt Coating by Euclid Chemical Company; Sealmastic by W.R. Meadows, Inc., or equal.

B. Bonding agents shall be epoxy adhesives conforming to the following products for the application specified:

1. For bonding freshly-mixed, plastic concrete to hardened concrete, Sikadur 32 Hi-Mod Epoxy Adhesive, as manufactured by Sika Corporation; Concresive Liquid (LPL), as manufactured by Master Builders; BurkEpoxy MV as manufactured by The Burke Company; or equal.

2. For bonding hardened concrete or masonry to steel, Sikadur 31 Hi-Mod Gel as manufactured by Sika Corporation; BurkEpoxy NS as manufactured by The Burke Company; Concresive Paste (LPL) as manufactured by Master Builders; or equal.

3. Crystalline waterproofing material shall be packaged in powder form and mixed with water for application as a cementitious slurry coating on concrete surfaces. The material shall chemically control and permanently fix non-soluble crystalline growth throughout the capillary voids in concrete. XYPEX CONCENTRATE as manufactured by Xypex Chemical Corporation, Richmomd, B.C. Canada [phone: (310) 643-5191], or VANDEX SUPER as manufactured by Vandex, Columbia, MD [phone: (800) 394-1410]

   Alternate crystalline waterproofing product will be accepted if it is in a powder form, requires only the addition of clean water, provides waterproofing by forming crystalline formations in the capillary voids in the concrete and is shown to be equivalent to the above-named products.

2.05 CONCRETE DESIGN REQUIREMENTS

A. General: Concrete shall be composed of cement, admixtures, aggregates and water. These materials shall be of the qualities specified. The exact proportions in which these materials are to be used for different parts of the Work will be determined during the trial batch. In general, the mix shall be designed to produce a concrete capable of being deposited so as to obtain maximum density and minimum shrinkage and, where deposited in forms, to have good consolidation properties and minimum shrinkage and maximum smoothness of surface. The aggregate gradations shall be formulated to provide fresh concrete that will not promote rock pockets around reinforcing steel or embedded items. The proportions shall be changed whenever necessary or desirable to meet the required results at no additional cost to the District. All changes shall be subject to review by the Engineer.

B. Fine Aggregate Composition: In mix designs for structural concrete, the percentage of fine aggregate in total aggregate by weight shall be as indicated in the following table.

Fine Aggregate

Fineness Modulus	Maximum Percent
2.7 or less	41
2.7 to 2.8	42
2.8 to 2.9	43
2.9 to 3.0	44

For other concrete, the maximum percentage of fine aggregate of total aggregate, by weight, shall not exceed 50.

C. Water-Cement Ratio and Compressive Strength: The minimum compressive strength and cement content of concrete shall be not less than that specified in the following tabulation.

Type of Work	Min. 28-Day Compressive Strength (psi)	Max. Aggregate Size (in)	Min. Cement Content per cu. yd. (lbs)	Max. W/C Ratio (by weight)
Structural concrete: foundation, walls, floor slabs, vaults, catch basins, equipment bases, manholes, piers, pre-cast components, and other reinforced structures or slabs.	3,250	1	560	.45
Sitework concrete: pavement; curb, gutter, walks; steel reinforced anchor/thrust blocks, encasements, cradles, cutoff walls.	2,500	1	520	0.50
Unreinforced concrete: thrust blocks, pipe bedding, pipe encasement, tunnel backfill.	2,000	1	376	0.62

N
O

NOTE: The Contractor is cautioned that the limiting parameters specified above are not a mix design. Additional cement or water reducing agent may be required to achieve workability demanded by the Contractor's construction methods and aggregates. The Contractor is responsible for any costs associated with furnishing concrete with the required workability.

D. Adjustments to Mix Design: The mixes used shall be changed whenever such change is necessary or desirable to secure the required strength, density, workability, and surface finish. The Contractor shall not be entitled to additional compensation because of such changes.

2.06 CONSISTENCY

The quantity of water entering into a batch of concrete shall be just sufficient, with a normal mixing period, to produce a concrete which can be worked properly into place without segregation, and which can be compacted by the vibratory methods herein specified to give the desired density, impermeability and smoothness of surface. The quantity of water shall be changed as necessary, with variations in the nature of moisture content of the aggregates, to maintain uniform production of a designed consistency. The consistency of the concrete in successive batches shall be determined by slump tests in accordance with ASTM C143. The slumps shall be as follows:

Part of Work	Slump (in)
Structural and site work concrete	4 inches, maximum

With high range water reducer added	6 inches ± 2 inches
Duct banks	5 inches ± inch

2.07 TRIAL BATCH AND LABORATORY TESTS

A. Before placing any concrete, a testing laboratory approved by the District shall prepare a trial batch of each class of structural concrete, based on the preliminary concrete mixes submitted by the Contractor. During the trail batch the aggregate proportions may be adjusted by the testing laboratory using the two coarse aggregate size ranges to obtain the required properties. If one size range produces an acceptable mix, a second mix size range need not be used. Such adjustments shall be considered refinements to the mix design and shall not be the basis for extra compensation to the Contractor. All concrete shall conform to the requirements of this Section, whether the aggregate proportions are from the Contractor's preliminary mix design, or whether the proportions have been adjusted during the trial batch process. The trial batch shall be prepared using the aggregates, cement and admixtures from the same source or manufacturer as proposed for the project. The trial batch materials shall be of a quantity such that the testing laboratory can obtain 3 drying shrinkage, and 6 compression test specimens from each batch. Trial batch testing required shall be performed at the expense of the Contractor.

B. The determination of compressive strength will be made by testing 6-inch diameter by 12-inch high cylinders; made, cured and tested in accordance with ASTM C192 and ASTM C39. Three compression test cylinders will be tested at 7 days and 3 at 28 days. The average compressive strength for the 3 cylinders tested at 28 days for any given trial batch shall not be less than 125 percent of the specified compressive strength.

C. A sieve analysis of the combined aggregate for each trial batch shall be performed according to the requirements of ASTM C136. Values shall be given for percent passing each sieve.

2.08 SHRINKAGE LIMITATION

A. The maximum concrete shrinkage for specimens cast in the laboratory from the trial batch, as measured at 21-day drying age or at 28-day drying age shall be 0.040 percent or 0.046 percent respectively. The Contractor shall only use a mix design for construction that has first met the trial batch shrinkage requirements. Shrinkage limitations apply only to structural concrete used as part of a hydraulic structure.

B. The maximum concrete shrinkage for specimens cast in the field shall not exceed the trial batch maximum shrinkage requirement by more than 20 percent.

C. If the required shrinkage limitation is not met during construction, the Contractor shall take any or all of the following actions, at no additional cost to the Engineer, for securing the specified shrinkage requirements. These actions may include changing the source or aggregates, cement and/or admixtures; reducing water content; washing of aggregate to reduce fines; increasing the number of construction joints; modifying the curing requirements; or other actions designed to minimize shrinkage or the effects of shrinkage.

2.09 MEASUREMENT OF CEMENT AND AGGREGATE

A. The amount of cement and of each separate size of aggregate entering into each batch of concrete shall be determined by direct weighing equipment furnished by the Contractor and acceptable to the Engineer.

B. Weighing tolerances:

Material	Percent of Total Weight
Cement	1
Aggregates	3
Admixtures	3

2.10 MEASUREMENT OF WATER

A. The quantity of water entering the mixer shall be measured by a suitable water meter or other measuring device of a type acceptable to the Engineer and capable of measuring the water in variable amounts within a tolerance of one percent. The water feed control mechanism shall be capable of being locked in position so as to deliver constantly any specified amount of water to each batch of concrete. A positive quick-acting valve shall be used for a cut-off in the water line to the mixer. The operating mechanism must be such that leakage will not occur when the valves are closed.

2.11 READY-MIXED CONCRETE

A. At the Contractor's option, ready-mixed concrete may be used meeting the requirements as to materials, batching, mixing, transporting, and placing as specified herein and in accordance with ASTM C94, including the following supplementary requirements.

B. Ready-mixed concrete shall be delivered to the site of the Work, and discharge shall be completed within one hour after the addition of the cement to the aggregates or before the drum has been revolved 250 revolutions, whichever is first.

C. Truck mixers shall be equipped with electrically-actuated counters by which the number of revolutions of the drum or blades may be readily verified. The counter shall be of the resetable, recording type, and shall be mounted in the driver's cab. The counters shall be actuated at the time of starting mixers at mixing speeds.

D. Each batch of concrete shall be mixed in a truck mixer for not less than 70 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed. All materials including mixing water shall be in the mixer drum before actuating the revolution counter for determining the number of revolution of mixing.

E. Truck mixers and their operation shall be such that the concrete throughout the mixed batch as discharged is within acceptable limits of uniformity with respect to consistency, mix, and grading. If slump tests taken at approximately the ¼ and ¾ points of the load

during discharge give slumps differing by more than one inch when the specified slump is 3 inches or less, or if they differ by more than 2 inches when the specified slump is more than 3 inches, the mixer shall not be used on the Work unless the causing condition is corrected and satisfactory performance is verified by additional slump tests. All mechanical details of the mixer, such as water measuring and discharge apparatus, condition of the blades, speed of rotation, general mechanical condition of the unit, and clearance of the drum, shall be checked before a further attempt to use the unit will be permitted.

F. Each batch of ready-mixed concrete delivered at the job site shall be accompanied by a delivery ticket furnished to the Engineer in accordance with the Paragraph in Part 1 entitled, "Delivery Tickets."

G. The use of non-agitating equipment for transporting ready-mixed concrete will not be permitted. Combination truck and trailer equipment for transporting ready-mixed concrete will not be permitted. The quality and quantity of materials used in ready-mixed concrete and in batch aggregates shall be subject to continuous inspection at the batching plant by the Engineer.

PART 3 - EXECUTION

3.01 PROPORTIONING AND MIXING

A. Proportioning: Proportioning of the concrete mix shall conform to the requirements of Chapter 3, "Proportioning" of ACI 301.

B. Mixing: Mixing of concrete shall conform to the requirements of Chapter 7 of ACI 301.

C. Slump: Maximum slumps shall be as specified herein.

D. Retempering: Retempering of concrete or mortar, which has partially hardened, shall not be permitted.

3.02 PREPARATION OF SURFACES FOR CONCRETING

A. General: Earth surfaces shall be thoroughly wetted by sprinkling, prior to the placing of any concrete, and these surfaces shall be kept moist by frequent sprinkling up to the time of placing concrete thereon. The surface shall be free from standing water, mud, and debris at the time of placing concrete.

B. Joints in Concrete: Refer to SSPWC Section 302-6.5, SSPWC Section 303-1.8.6, and SSPWC Section 303-5.4 for joint requirements. Construction joints are defined as concrete surfaces upon or against which concrete is to be placed where the placement of the concrete has been stopped or interrupted so that, as determined by the Engineer, the new concrete cannot be incorporated integrally with that previously placed. The surfaces of horizontal joints shall be given a compacted, roughened surface for good bond. Except where the Drawings call for joint surfaces to be coated, the joint surfaces shall be cleaned of all laitance, loose or defective concrete, and foreign material and roughened to a minimum ¼-inch amplitude. Such cleaning and roughening shall be accomplished by hydroblasting or abrasive blasting (exposing aggregate) followed by thorough washing.

All pools of water shall be removed from the surface of construction joints before the new concrete is placed.

C. The surface between the reservoir floor and column joint shall be screeded with a steel brush after the initial set of concrete. Screeding shall be postponed until the laitance of the concrete can be fully removed. Heavy abrasive blasting may be done in lieu of the above and with the approval of the District. Curing compounds, if used, that have been deposited in the keys shall be removed by abrasive blasting prior to pouring the footing concrete.

D. Placing Interruptions: When placing of concrete is to be interrupted long enough for the concrete to take a set, the working face shall be given a shape by the use of forms or other means that will secure proper union with subsequent Work provided that construction joints shall be made only where acceptable to the Engineer.

E. Embedded Items: No concrete shall be placed until all formwork, installation of parts to be embedded, reinforcement steel, and preparation of surfaces involved in the placing have been completed and accepted by the Engineer at least 4 hours before placement of concrete. All surfaces of forms and embedded items that have become encrusted with dried grout from concrete previously placed shall be cleaned of all such grout before the surrounding or adjacent concrete is placed.

F. All inserts or other embedded items shall conform to the requirements herein.

G. All reinforcement, anchor bolts, sleeves, inserts, and similar items shall be set and secured in the forms where shown or by shop drawings and shall be acceptable to the Engineer before any concrete is placed. Accuracy of placement is the responsibility of the Contractor.

H. Casting New Concrete Against Old: Where concrete is to be cast against old concrete (any concrete which is greater than 60 days of age), the surface of the old concrete shall be thoroughly cleaned and roughened by hydro-blasting or abrasive blasting (exposing aggregate). The joint surface shall be coated with a bonding agent unless indicated otherwise by the Engineer.

I. No concrete shall be placed in any structure until all water entering the space to be filled with concrete has been properly cut off or has been diverted by pipes, or other means, and carried out of the forms, clear of the Work. No concrete shall be deposited underwater nor shall the Contractor allow still water to rise on any concrete until the concrete has attained its initial set. Water shall not be permitted to flow over the surface of any concrete in such manner and at such velocity as will injure the surface finish of the concrete. Pumping or other necessary dewatering operations for removing groundwater, if required, will be subject to the review of the Engineer.

J. Corrosion Protection: Pipe, conduit, dowels, and other ferrous items required to be embedded in concrete construction shall be so positioned and supported prior to placement of concrete that there will be a minimum of 2 inches clearance between said items and any part of the concrete reinforcement. Securing such items in position by wiring or welding them to the reinforcement will not be permitted.

K. Openings for pipes, inserts for pipe hangers and brackets, and the setting of anchors shall, where practicable, be provided for during the placing of concrete.

L. Anchor bolts shall be accurately set, and shall be maintained in position by templates while being embedded in concrete.

M. Cleaning: The surfaces of all metalwork to be in contact with concrete shall be thoroughly cleaned of all dirt, grease, loose scale and rust, grout, mortar, and other foreign substances immediately before the concrete is placed.

3.03 HANDLING, TRANSPORTING, AND PLACING

A. General: Placing of concrete shall conform to the applicable requirements of Chapter 8 of ACI 301 and the requirements of this Section. No aluminum materials shall be used in conveying any concrete. Do not place concrete during rainstorms. Protect concrete placed immediately before rain to prevent rainwater from coming in contact with it. Keep sufficient protective covering on hand at all times for this purpose.

B. Non-Conforming Work or Materials: Concrete which upon or before placing is found not to conform to the requirements specified herein shall be rejected and immediately removed from the Work. Concrete which is not placed in accordance with these Specifications or which is of inferior quality shall be removed and replaced by and at the expense of the Contractor.

C. Unauthorized Placement: No concrete shall be placed except in the presence of duly authorized representative of the Engineer. The Contractor shall notify the Engineer in writing at least 24 hours in advance of placement of any concrete.

D. Placement in Wall Forms: Concrete shall not be dropped through reinforcement steel or into any deep form, nor shall concrete be placed in any form in such a manner as to leave accumulation of mortar on the form surfaces above the placed concrete. In such cases, some means such as the use of hoppers and, if necessary, vertical ducts of canvas, rubber, or metal shall be used for placing concrete in the forms in a manner that it may reach the place of final deposit without separation. In no case shall the free fall of concrete exceed 8 feet below the ends of ducts, chutes, or buggies. Concrete shall be uniformly distributed during the process of depositing and in no case after depositing shall any portion be displaced in the forms more than 6 feet in horizontal direction. Concrete in forms shall be deposited in uniform horizontal layers not deeper than 2 feet; and care shall be taken to avoid inclined layers or inclined construction joints except where such are required for sloping members. Each layer shall be placed while the previous layer is still soft. The rate of placing concrete in forms shall not exceed the design rate of vertical rise. Sufficient illumination shall be provided in the interior of all forms so that the concrete at the places of deposit is visible from the deck or runway.

A wall section may be cast against an adjacent wall section after a minimum of 24 hours has elapsed after the completion of the previous wall section.

E. Casting New Concrete Against Old: An epoxy adhesive bonding agent shall be applied to the old surfaces according to the manufacturer’s written recommendations. This provision shall not apply to joints where waterstop is installed. No horizontal joints will be permitted in reservoir corewall sections.

F. Conveyor Belts and Chutes: All ends of chutes, hopper gates, and all other points of concrete discharge throughout the Contractor's conveying, hoisting and placing system shall be so designed and arranged that concrete passing from them will not fall separated into whatever receptacle immediately receives it. Conveyor belts, if used, shall be of a type acceptable to the Engineer. Chutes longer than 50 feet will not be permitted. Minimum slopes of chutes shall be such that concrete of the specified consistency will readily flow in them. If a conveyor belt is used, it shall be wiped clean by a device operated in such a manner that none of the mortar adhering to the belt will be wasted. All conveyor belts and chutes shall be covered.

G. Placement in Columns: Concrete in circular spirally-tied columns, having no horizontal reinforcement crossing into the region bounded by the vertical reinforcement, may be deposited from the top of the column form, at Contractor's option such that no separation of the coarse aggregate from the mortar takes place. All concrete shall be vibrated as required herein. The final quality of the poured concrete column shall be the responsibility of the Contractor. If the quality of the column is found to be unacceptable, the District, at the Contractor's expense, may require the complete removal of the column and may require that an alternate placement method be used.

H. Placement in Reservoir Wall and Column Sections: Wall and column pours shall immediately be preceded with a cement rich concrete layer of 1-inch average thickness at walls and columns consisting of water, and 8 sacks of cement per cubic yard. Sand and fine aggregate shall be added equally to the mix with a maximum slump of 8 inches. Compressive strength of cement-rich concrete shall be the equal to that required for the remainder of the pour.

I. Placement in Slabs: Concrete placed in sloping slabs shall proceed uniformly from the bottom of the slab to the top, for the full width of the placement. As the Work progresses, the concrete shall be vibrated and carefully worked around the slab reinforcement, and the surface of the slab shall be screeded in an up-slope direction.

J. Temperature of Concrete: The temperature of concrete when it is being placed shall be not more than 90 degrees F nor less than 55 degrees F for sections less than 12 inches thick nor less than 50 degrees F for all other sections. Concrete ingredients shall not be heated to a temperature higher than that necessary to keep the temperature of the mixed concrete, as placed, from falling below the specified minimum temperature. When the temperature of the concrete is 85 degrees F or above, the time between the introduction of the cement to the aggregates and discharge shall not exceed 45 minutes. If concrete is placed when the weather is such that the temperature of the concrete would exceed 90 degrees F, the Contractor shall employ effective means, such as precooling of aggregates and mixing water using ice or placing at night, as necessary to maintain the temperature of the concrete, as it is placed, below 90 degrees F. The Contractor shall be entitled to no additional compensation on account of the foregoing requirements.

K. Hot Weather Placement:

1. Hot weather is defined as any combination of high air temperature, low relative humidity and wind velocity tending to impair the quality of fresh or hardened concrete or otherwise result in abnormal concrete properties. During hot weather, any or all of the methods specified herein for temperature control of

concrete shall be used as required to maintain the concrete temperature below the limits specified.

2. Aggregate piles, cement bins and batch plant bins shall be shaded from direct rays of the sun. Aggregate piles shall be cooled by wetting with water and evaporation. Aggregate wetting shall be performed in such a manner that it will not cause wide variation in moisture content impairing slump uniformity.

3. Concrete water shall be refrigerated or ice shall be added to the mix, up to 100 percent of the water requirement. Ice shall be in such a form that it will be completely melted and dispersed throughout the mix at the completion of the mixing time. The mix time shall be held to the minimum practicable consistent with producing concrete meeting the specified requirements.

4. Elevated forms, reinforcing steel and similar members shall be cooled by fog spray and evaporation immediately prior to placing of concrete. Forms shall be free of standing water when concrete is placed.

5. Concrete shall be deposited in the Construction within 60 minutes after completion of mixing.

6. The Contractor shall provide a fog spray of water on the exposed surface of concrete prior to its initial set when site conditions produce a rate of evaporation of 0.2 lbs./sq. ft./hr. as determined by Figure 2.1.5 of ACI 305R, to prevent plastic shrinkage cracks in the concrete.

7. Fog spray shall be used after finishing and before the specified curing is commenced to avoid surface drying.

8. There shall be no additional reimbursement to the Contractor for costs incurred for placing concrete in hot weather.

L. Cold Weather Placement:

1. Placement of concrete shall conform to ACI 306.1 – Standard Specification for Code Weather Concreting, and the following.

2. Remove all snow, ice and frost from the surfaces, including reinforcement, against which concrete is to be placed. Before beginning concrete placement, thaw the subgrade to a minimum depth of 6 inches. All reinforcement and embedded items shall be warmed to above 32 degrees F prior to concrete placement.

3. Maintain the concrete temperature above 50 degrees F for at least 3 days after placement.

M. Crystalline Waterproofing Application

1. The waterproofing material shall be mixed, applied and cured as recommended by the manufacturer.

2. The surface to receive the waterproofing shall be prepared as recommended by the manufacturer. The waterproofing shall be mixed to a slurry consistency and brushed onto the surfaces specified where the waterproofing is required at a cold joint. When brushing the slurry into the substrate, it should be worked into all holes and crevices in the surface.

3. Where the waterproofing is required in a continuous groove, a slurry coat of waterproofing shall be applied to the groove surface. The prepared groove shall then be packed with a "dry pack" consistency mix flush with the surrounding surface.

3.04 PUMPING OF CONCRETE

A. General: If the pumped concrete does not produce satisfactory end results, the Contractor shall discontinue the pumping operation and proceed with the placing of concrete using conventional methods.

B. Pumping Equipment: The pumping equipment must have 2 cylinders and be designed to operate with one cylinder only in case the other one is not functioning. In lieu of this requirement, the Contractor may have a standby pump on the site during pumping.

C. The minimum diameter of the hose (conduits) shall be in accordance with ACI 304.2R.

D. Pumping equipment and hoses (conduits) that are not properly functioning shall be replaced.

E. Aluminum conduits for conveying the concrete shall not be permitted.

F. Field Control: Concrete samples for slump, air content, and test cylinders will be taken at the placement (discharge) end of the line.

G. Before pumping is started, prime the delivery pipe or hose by pumping mortar through the line using 5 gallons of mortar for each 50 feet of delivery line. Do not deposit mortar in forms.

3.05 ORDER OF PLACING CONCRETE

A. The order of placing concrete in all parts of the Work shall be acceptable to the Engineer. In order to minimize the effects of shrinkage, the concrete shall be placed in units as bounded by construction joints shown. The placing of units in slabs shall be done by placing alternate units in a manner such that each unit placed shall have cured at least 3 days for hydraulic structures and 2 days for all other structures before the contiguous unit or units are placed. Corner sections of vertical walls shall not be placed until the 2 adjacent wall panels have cured at least 7 days for hydraulic structures and 4 days for all other structures.

B. The surface of the concrete shall be level whenever a run of concrete is stopped. To insure a level, straight joint on the exposed surface of walls, a wood strip at least ¾-inch thick shall be tacked to the forms on these surfaces. The concrete shall be carried about ½-inch above the underside of the strip. About one hour after the concrete is placed, the

strip shall be removed and any irregularities in the edge formed by the strip shall be leveled with a trowel and all laitance shall be removed.

3.06 TAMPING AND VIBRATING

A. As concrete is placed in the forms or in excavations, it shall be thoroughly settled and compacted, throughout the entire depth of the layer which is being consolidated, into a dense, homogenous mass, filling all corners and angles, thoroughly embedding the reinforcement, eliminating rock pockets, and bringing only a slight excess of water to the exposed surface of concrete during placement. Vibrators shall be Group 3 (per ACI 309) high speed power vibrators (8,000 to 12,000 rpm) of an immersion type in sufficient number and with (at least one) standby units as required. Group 2 vibrators may be used only at specific locations when accepted by the Engineer.

B. Care shall be used in placing concrete around waterstops. The concrete shall be carefully worked by rodding and vibrating to make sure that all air and rock pockets have been eliminated. Where flat-strip type waterstops are placed horizontally, the concrete shall be worked under the waterstops by hand, making sure that all air and rock pockets have been eliminated. Concrete surrounding the waterstops shall be given additional vibration, over and above that used for adjacent concrete placement to assure complete embedment of the waterstops in the concrete.

C. Concrete in walls and columns shall be internally vibrated and at the same time rammed, stirred, or worked with suitable appliances, tamping bars, shovels, or forked tools until it completely fills the forms or excavations and closes snugly against all surfaces. Subsequent layers of concrete shall not be placed until the layers previously placed have been worked thoroughly as specified. Vibrators shall be provided in sufficient numbers, with standby units as required, to accomplish the results herein specified within 15 minutes after concrete of the prescribed consistency is placed in the forms. Each layer of concrete in walls and columns shall be vibrated thoroughly before the next layer may be placed thereon. Vibrators shall be taken through the top layer down through the full layer thickness below to insure proper integration of the concrete and to avoid the development of cold joints and honeycomb between the layers. In other words, each layer of concrete shall be vibrated at least twice. The vibrating head shall be kept from contact with the surfaces of the forms. Care shall be taken not to vibrate concrete excessively or to work it in any manner that causes segregation of its constituents.

D. Vibration shall be performed at each required pour window opening in the form wall for the reservoir and elsewhere, where occurs.

3.07 FINISHING CONCRETE SURFACES

A. General: Surfaces shall be free from fins, bulges, ridges, offsets, honeycombing, or roughness of any kind, and shall present a finished, smooth, continuous hard surface. Allowable deviations from plumb or level and from the alignment, profiles, and dimensions shown are defined as tolerances and are specified in Part 1, herein. These tolerances are to be distinguished from irregularities in finish as described herein. Aluminum finishing tools shall not be used.

B. Formed Surfaces: No treatment is required after form removal except for curing, repair of defective concrete, and treatment of surface defects. Where architectural finish is required, it shall be as specified or shown.

1. Surface holes larger than 1/2-inch in diameter or deeper than 1/4-inch are defined as surface defects in basins and exposed walls.

C. Unformed Surfaces: After proper and adequate vibration and tamping, all unformed top or permanently exposed surfaces of slabs, floors, walls, and curbs shall be brought to a uniform surface with suitable tools. Immediately after the concrete has been screeded, it shall be treated with a liquid evaporation retardant. The retardant shall be used again after each work operation as necessary to prevent drying shrinkage cracks. The classes of finish specified for unformed concrete surfaces are designated and defined as follows:

1. Finish U1 – Sufficient leveling and screeding to produce an even, uniform surface with surface irregularities not to exceed 3/8-inch. No further special finish is required.

2. Finish U2 – After sufficient stiffening of the screeded concrete, surfaces shall be float finished with wood or metal floats or with a finishing machine using float blades. Excessive floating of surfaces while the concrete is plastic and dusting of dry cement and sand on the concrete surface to absorb excess moisture will not be permitted. Floating shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture. Surface irregularities shall not exceed ¼-inch. Joints and edges shall be tooled where shown or as determined by the Engineer. Floating shall be performed as soon as possible to prevent premature drying of the surface prior to applying the required curing membrane.

3. Finish U3 – After the floated surface (as specified for Finish U2) has hardened sufficiently to prevent excess of fine material from being drawn to the surface, steel troweling shall be performed with firm pressure such as will flatten the sandy texture of the floated surface and produce a dense, uniform surface free from blemishes, ripples, and trowel marks. The finish shall be smooth and free of all irregularities.

4. Finish U4 – Steel trowel finish (as specified for Finish U3) without local depressions or high points. In addition, the surface shall be given a medium-broom finish with brooming perpendicular to drainage unless otherwise shown. The resulting surface shall be rough enough to provide a non-skid finish.

D. Unformed surfaces shall be finished according to the following schedule:

UNFORMED SURFACE FINISH SCHEDULE

Area	Finish
Grade slabs and foundations to be covered with concrete or fill material	U1
Floors to be covered with grouted tile or topping grout	U2

Slabs or footings which are water bearing with slopes 10 percent or less	U3
Sloping slabs which are water bearing with slopes greater than 10 percent	U4
Slabs not water bearing	U4
Slabs to be covered with built-up roofing	U2

UNFORMED SURFACE FINISH SCHEDULE

Area	Finish
Interior slabs and floors to receive architectural finish	U3
Top surface of walls	U3

3.08 CURING

A. General: All concrete shall be cured for not less than 7 days after placing, in accordance with the methods specified herein for the different parts of the Work, and described in detail in the following paragraphs:

Surface to be Cured	Method
Unstripped forms	1
Wall sections and columns with forms removed	3
Construction joints between floor and walls, and between floor slab and columns	3
Easement concrete and thrust blocks	2
All concrete surfaces not specifically provided for elsewhere in this Paragraph	4
Floor slabs on grade in hydraulic structures, wall and column footings	5
Slabs not on grade	5

B. Method 1: Wooden forms shall be wetted immediately after concrete has been placed and shall be kept wet with water until removed. If steel forms are used the exposed concrete surfaces shall be kept continuously wet until the forms are removed. If forms are removed within 7 days of placing the concrete, curing shall be continued in accordance with Method 5, herein.

C. Method 2: The surface shall be covered with moist earth not less than 4 hours, nor more than 24 hours, after the concrete is placed. Earthwork operations that may damage the concrete shall not begin until at least 7 days after placement of concrete.

D. Method 3: The surface shall be sprayed with a liquid curing compound.

1. It shall be applied in accordance with the manufacturer's printed instructions at a maximum coverage rate of 200 square feet per gallon and in such a manner as to cover the surface with a uniform film which will seal thoroughly.

2. Where the curing compound method is used, care should be exercised to avoid damage to the seal during the 7-day curing period. Should the seal be damaged or broken before the expiration of the curing period, the break shall be repaired immediately by the application of additional curing compound over the damaged portion.

3. Wherever curing compound may have been applied by mistake to surfaces against which concrete subsequently is to be placed and to which it is to adhere, said compound shall be entirely removed by wet sandblasting just prior to the placing of new concrete.

4. Where curing compound is specified, it shall be applied as soon as the concrete has hardened enough to prevent marring or unformed surfaces, and within 2 hours after removal of forms from formed surfaces. Repairs required to be made to formed surfaces shall be made within the said 2-hour period; provided, however, that any such repairs which cannot be made within the said 2-hour period shall be delayed until after the curing compound has been applied. When repairs are to be made to an area on which curing compound has been applied, the area involved shall first be wet-sandblasted to remove the curing compound, prior to the repairs shall be made as specified herein.

5. At all locations where concrete is placed adjacent to a panel which has been coated with curing compound, the previously coated panel shall have curing compound reapplied to an area within 6 feet of the joint and to any other location where the curing membrane has been disturbed.

6. Prior to final acceptance of the Work, all visible traces of curing compound shall be removed from all surfaces in such a manner that does not damage surface finish.

E. Method 4:

1. Until the concrete surface is covered with curing compound, the entire surface shall be kept damp by applying water, using nozzles that atomize the flow so that the surface is not marred or washed. The concrete shall be given a coat of curing compound in accordance with Method 3, herein. Not less than one hour nor more than 4 hours after the coat of curing compound has been applied, the surface shall be wetted with water delivered through a fog nozzle, and concrete-curing blankets shall be placed on the slabs. The curing blankets shall be polyethylene sheet, polyethylene-coated waterproof paper sheeting or polyethylene-coated burlap. The blankets shall be laid with the edges butted together and the joints between strips sealed with 2-inch wide strips of sealing tape or with edges lapped not less than 3 inches and fastened together with a waterproof cement to form a continuous watertight joint.

2. The curing blankets shall be left in place during the 7-day curing period and shall not be removed until after concrete for adjacent Work has been placed. Should

the curing blankets become torn or otherwise ineffective, the Contractor shall replaced damaged sections. During the first 3 days of the curing period, no traffic of any nature and no depositing, temporary or otherwise, of any materials shall be permitted on the curing blankets. During the remainder of the curing period, foot traffic and temporary depositing of materials that impose light pressure will be permitted only on top of plywood sheets 5/8-inch minimum thickness, laid over the curing blanket. The Contractor shall add water under the curing blanket as often as necessary to maintain damp concrete surfaces at all times.

F. Method 5: This method applies to both walls and slabs.

1. The concrete shall be kept continuously wet by the application of water for a minimum period of at least 7 consecutive days beginning immediately after the concrete has reached final set or forms have been removed.

2. Until the concrete surface is covered with the curing medium, the entire surface shall be kept damp by applying water, using nozzles that atomize the flow so that the surface is not marred or washed.

3. Heavy curing mats shall be used as a curing medium to retain the moisture during the curing period. The curing medium shall be weighted or otherwise held in place to prevent being dislodged by wind or any other causes and to be substantially in contact with the concrete surface. All edges shall be continuously held in place.

4. The curing blankets and concrete shall be kept continuously wet by the use of sprinklers or other means both during and after normal working hours.

5. Immediately after the application of water has terminated at the end of the curing period, the curing medium shall be removed, any dry spots shall be rewetted, and curing compound shall be immediately applied in accordance with Method 4 herein.

6. The Contractor shall dispose of excess water from the curing operation to avoid damaged to the Work.

3.09 PROTECTION

A. The Contractor shall protect all concrete against injury until final acceptance by the Engineer.

B. Fresh concrete shall be protected from damage due to rain, hail, sleet, or snow. The Contractor shall provide such protection while the concrete is still plastic and whenever such precipitation is imminent or occurring.

3.10 CURING IN COLD WEATHER

A. Water curing of concrete may be reduced to 6 days during periods when the mean daily temperature in the vicinity of the worksite is less than 40 degrees F; provided that, during

the prescribed period of water curing, when temperatures are such that concrete surfaces may freeze, water curing shall be temporarily discontinued.

B. Concrete cured by an application of curing compound will require no additional protection from freezing if the protection at 50 degrees F for 72 hours is obtained by means of approved insulation in contact with the forms of concrete surfaces; otherwise the concrete shall be protected against freezing temperatures for 72 hours immediately following 72 hours protection at 50 degrees F. Concrete cured by water curing shall be protected against freezing temperatures for 3 days immediately following the 72 hours of protection at 50 degrees F.

C. Discontinuance of protection against freezing temperatures shall be such that the drop in temperature of any portion of the concrete will be gradual and will not exceed 40 degrees F in 24 hours. In the spring, when the mean daily temperature rises above 40 degrees F for more than 3 successive days, the specified 72-hour protection at a temperature not lower than 50 degrees F may be discontinued for as long as the mean daily temperature remains above 40 degrees F; provided, that the concrete shall be protected against freezing temperatures for not less than 48 hours after placement.

D. Where artificial heat is employed, special care shall be taken to prevent the concrete from drying. Use of unvented heaters will be permitted only when unformed surfaces of concrete adjacent to the heaters are protected for the first 24 hours from an excessive carbon dioxide atmosphere by application of curing compound; provided, that the use of curing compound for such surfaces is otherwise permitted by these specifications.

3.11 TREATMENT OF SURFACE DEFECTS

A. As soon as forms are removed, all exposed surfaces shall be carefully examined and any irregularities shall be immediately rubbed or ground in a satisfactory manner in order to secure a smooth, uniform, and continuous surface. Plastering or coating of surfaces to be smoothed will not be permitted. No repairs shall be made until after inspection by the Engineer. In no case will extensive patching of honeycombed concrete be permitted. Concrete containing minor voids, holes, honeycombing, or similar depression defects shall have them repaired as specified herein. Concrete containing extensive voids, holes, honeycombing, or similar depression defects, shall be completely removed and replaced. The Contractor, at its own expense, shall promptly execute all repairs and replacements herein specified after inspection by the Engineer.

B. Defective surfaces to be repaired shall be cut back from trueline a minimum depth of ½ inch over the entire area. Feathered edges will not be permitted. Where chipping or cutting tools are not required in order to deepen the area properly, the surface shall be prepared for bonding by the removal of laitance or soft material, and not less than 1/32 inch depth of the surface film from all hard portions, by means of an efficient sandblast. After cutting and sandblasting, the surface shall be wetted sufficiently in advance of shooting with shotcrete or with cement mortar so that while the repair material is being applied, the surfaces under repair will remain moist, but not so wet as to overcome the suction upon which a good bond depends. The material used for repair proposed shall consist of a mixture of one sack of cement to 3 cubic feet of sand. For exposed walls, the cement shall contain such a proportion of Atlas white portland cement as is required to make the color of the patch match the color of surrounding concrete.

C. Holes left by tie-rod cones shall be reamed with suitable toothed reamers so as to leave the surfaces of the holes clean and rough. These holes then shall be repaired in an approved manner with dry-packed cement grout. Holes left by form-tying devices having a rectangular cross-section, and other imperfections having a depth greater than their last surface dimension, shall not be reamed but shall be repaired in an approved manner with dry-packed cement grout.

D. All repairs shall be built up and shaped in such a manner that the completed Work will conform to the requirements of this Section, as applicable, using approved methods which will not disturb the bond, cause sagging, or cause horizontal fractures. Surfaces of said repairs shall receive the same kind and amount of curing treatment as required for the concrete in the repaired section.

E. Prior to filling any structure with water, all cracks that may have developed shall be "vee'd" and filled with sealant conforming to the requirements of SSPWC Section 302-6.5, SSPWC Section 303-1.8.6, and SSPWC Section 303-5.4 for joint requirements. This repair method shall be done on the water bearing face of members. Prior to backfilling, faces of members in contact with fill, which are not covered with a waterproofing membrane, shall also have cracks repaired as specified herein.

3.12 PATCHING HOLES IN CONCRETE

A. Patching Small Holes:

1. Holes which are less than 12 inches in their least dimension and extend completely through concrete members shall be filled as specified herein.

2. Small holes in members which are water-bearing or in contact with soil or other fill material shall be filled with non-shrink grout. Where a face of the member is exposed to view, the non-shrink grout shall be held back 2 inches from the finished surface. The remaining 2 inches shall then be patched according to the Paragraph in Part 3 entitled "Treatment of Surface Defects".

3. Small holes through all other concrete members shall be filled with non-shrink grout, with exposed faces treated as above.

B. Patching Large Holes:

1. Holes which are larger than 12 inches in their least dimension, shall have a keyway chipped into the edge of the opening all around, unless a formed keyway exists. The holes shall then be filled with concrete as specified herein.

2. Holes which are larger than 24 inches in their least dimension and which do not have reinforcing steel extending from the existing concrete, shall have reinforcing steel set in grout in drilled holes. The reinforcing added shall match the reinforcing in the existing section unless ordered otherwise.

3.13 CARE AND REPAIR OF CONCRETE

The Contractor shall protect all concrete against injury or damage from excessive heat, lack of moisture, overstress, or any other cause until final acceptance by the Engineer. Particular care

shall be taken to prevent the drying of concrete and to avoid roughening or otherwise damaging the surface. Any concrete found to be damaged, or which may have been originally defective, or which becomes defective at any time prior to the final acceptance of the completed Work, or which departs from the established line or grade, or which, for any other reason, does not conform to the requirements of the Contract Documents, shall be satisfactorily repaired or removed and replaced with acceptable concrete at the Contractor's expense.

END OF SECTION

SECTION 03315

GROUT

PART 1 - GENERAL

1.01 DESCRIPTION

A. The Contractor shall furnish all materials for grout in accordance with the provisions of this Section and shall form, mix, place, cure, repair, finish, and do all other Work as required to produce finished grout, in accordance with the requirements of the Contract Documents. The Contract Documents shall take precedence over these specifications.

B. The following type of grout shall be covered in this Section:

1. Non-Shrink Grout: This type of grout is to be used wherever grout is shown in the Contract Documents, unless another type is specifically referenced.

2. Cement Grout

3. Epoxy Grout

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

The publications listed below form part of this specification to the extent referenced and are referred to in the text by the basic designation only. Reference shall be made to the latest edition of said standards unless otherwise called for.

CRD-C 621	Corps of Engineers Specification for Non-Shrink Grout
ASTM C 109	Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in or 50-mm Cube Specimens)
ASTM C 531	Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical- Resistant Mortars, Grouts, and Monolithic Surfaces
ASTM C 579	Test Methods for Compressive Strength of Chemical-Resistant Mortars and Monolithic Surfaces
ASTM C 827	Test Method for Early Volume Change of Cementitious Mixtures
ASTM D 696	Test Method for Coefficient of Linear Thermal Expansion of Plastics

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300 – Contractor Submittals

B. Section 01410 – Testing Laboratory Services

C. Section 03300 – Cast-In-Place Concrete

1.04 CONTRACTOR SUBMITTALS

The Contractor shall submit certified test results verifying the compressive strength, shrinkage, and expansion requirements specified herein; and manufacturer's literature containing instructions and recommendations on the mixing, handling, placement and appropriate uses for each type of non-shrink and epoxy grout used in the Work.

1.05 QUALITY ASSURANCE

A. Field Tests:

1. Compression test specimens will be taken during construction from the first placement of each type of grout, and at intervals thereafter as selected by the Engineer to insure continued compliance with these specifications.

2. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C109 at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at 7 days, 28 days, and each additional time period as appropriate.

3. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C579, Method B, at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at 7 days, and each earlier time period as appropriate.

4. All grout, already placed, which fails to meet the requirements of these specifications, is subject to removal and replacement at the cost of the Contractor.

5. The cost of all laboratory tests on grout will be borne by the Contractor. The Contractor shall supply all materials necessary for fabricating the test specimens.

B. Construction Tolerances: Construction tolerances shall be as specified in the Section 03300 except as modified herein and elsewhere in the Contract Documents.

PART 2 - PRODUCTS

2.01 CEMENT GROUT

A. Cement Grout: Cement grout shall be composed of one part cement, three parts sand, and the minimum amount of water necessary to obtain the desired consistency. Where needed to match the color of adjacent concrete, white portland cement shall be blended with regular cement as needed. The minimum compressive strength at 28 days shall be 4000 psi.

B. Cement grout materials shall be as specified in Section 03300.

2.02 PREPACKAGED GROUTS

A. Non-Shrink Grout:

1. Non-shrink grout shall be prepackaged, inorganic, non-gas-liberating, non-metallic, cement-based grout requiring only the addition of water. Manufacturer's instructions shall be printed on each bag or other container in which the materials are packaged. The specific formulation for each class of non-shrink grout specified herein shall be that recommended by the manufacturer for the particular application.

2. Class A non-shrink grouts shall have a minimum 28-day compressive strength of 5000 psi; shall have no shrinkage (0.0 percent) and a maximum 4.0 percent expansion in the plastic state when tested in accordance with ASTM C-827; and shall have no shrinkage (0.0 percent) and a maximum of 0.2 percent expansion in the hardened state when tested in accordance with CRD C 621.

3. Class B non-shrink grouts shall have a minimum 28-day compressive strength of 5000 psi and shall meet the requirements of CRD C 621.

4. Application:

   a. Class A non-shrink grout shall be used for the repair of all holes and defects in concrete members which are water bearing or in contact with soil or other fill material, grouting under all equipment base plates, and at locations where grout is specified in the contract documents; except, for those applications for Class B non-shrink grout and epoxy grout specified herein. Class A non-shrink grout may be used in place of Class B non-shrink grout for all applications.

   b. Class B non-shrink grout shall be used for the repair of all holes and defects in concrete members which are not water-bearing and not in contact with soil or other fill material, and grouting under all base plates for structural steel members.

B. Epoxy Grout:

1. Application: Epoxy grout shall be used to embed all anchor bolts and reinforcing steel required to be set in grout, and for all other applications required in the Contract Documents.

2. Epoxy grout shall be a pourable, non-shrink, 100 percent solids system. The epoxy grout system shall have three components: resin, hardener, and especially blended aggregate, all premeasured and prepackaged. The resin component shall not contain any non-reactive diluents. Resins containing butyl glycidyl ether (BGE) or other highly volatile and hazardous reactive diluents are not acceptable. Variation of component ratios is not permitted unless specifically recommended by the manufacturer. Manufacturer's instructions shall be printed on each container in which the materials are packaged.

3. The chemical formulation of the epoxy grout shall be that recommended by the manufacturer for the particular application.

4. The mixed epoxy grout system shall have a minimum working life of 45 minutes at 75 degrees F.

5. The epoxy grout shall develop a compressive strength of 5,000 psi in 24 hours and 10,000 psi in seven days when tested in accordance with ASTM C579, Method B. There shall be no shrinkage (0.0 percent) and a maximum 4.0 percent expansion when tested in accordance with ASTM C827.

6. Epoxy grout shall be BurkEpoxy Anchoring Grout by the Burke Company, Hilti HY-150, Simpson SET or I.C.B.O. approved equal.

2.03 CURING MATERIALS

Curing materials shall be as specified in Section 03300 for cement grout and as recommended by the manufacturer of prepackaged grouts.

2.04 CONSISTENCY

A. The consistency of grouts shall be that necessary to completely fill the space to be grouted for the particular application. Dry pack consistency is such that the grout is plastic and moldable, but will not flow. Where "dry pack" is called for in the Contract Documents, if shall mean a grout of that consistency; the type of grout to be used shall be as specified herein for the particular application.

B. The slump for topping grout and concrete fill shall be adjusted to match placement and finishing conditions, but shall not exceed 4 inches.

2.05 MEASUREMENT OF INGREDIENTS

A. Measurements for cement grout shall be made accurately by volume using containers. Shovel measurement shall not be allowed

B. Prepackaged grouts shall have ingredients measured by means recommended by the manufacturer.

PART 3 - EXECUTION

3.01 GENERAL

A. All surface preparation, curing, and protection of cement grout shall be as specified in Section 03300. The finish of the grout surface shall match that of the adjacent concrete.

B. The manufacturer of Class A non-shrink grout and epoxy shall provide on-site technical assistance upon request.

C. Base concrete must have attained its design strength before grout is placed, unless authorized by the Engineer.

3.02 GROUTING PROCEDURES

A. Prepackaged Grouts: All mixing, surface preparation, handling, placing, consolidation, curing, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.

B. Base Plate Grouting:

1. For base plates, the original concrete shall be blocked out or finished off a sufficient distance below the plate to provide for a one-inch thickness of grout or a thickness as shown on the Drawings.

2. After the base plate has been set in position at the proper elevation by steel wedges or double nuts on the anchor bolts, the space between the bottom of the plate and original pour of concrete shall be filled with non-shrink-type grout. The mixture shall be a trowelable consistency and tamped or rodded solidly into the space between the plate and the base concrete. A backing board or stop shall be provided at the back side of the space to be filled with grout. Where this method of placement is not practical or where required by the Engineer, alternate grouting methods shall be submitted for acceptance by the Engineer.

3.03 CONSOLIDATION

Grout shall be placed in such a manner, for the consistency necessary for each application, so as to assure that the space to be grouted is completely filled.

END OF SECTION

SECTION 03460

PRECAST CONCRETE SEWER MANHOLES

PART 1 - GENERAL

1.01 DESCRIPTION

A. The CONTRACTOR shall provide precast concrete sewer manholes, also referred to as access holes, complete and in place, in accordance with the DISTRICT standard drawings.

1.02 RELATED SECTIONS

A. The Work of the following Sections applies to the Work of this Section. Other Sections, not referenced below, shall also apply to the extent required for proper performance of this Work.

1. Section 01300 – Shop Drawings and Submittals
2. Section 02350 – Excavation Support Systems
3. Section 03300 – Cast-in-Place Concrete
4. Section 09801 – Manhole Lining

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. The publications listed below form part of this specification to the extent referenced and are referred to in the text by the basic designation only. Reference shall be made to the latest edition of said standards unless otherwise called for.

1. ASTM A48 – Standard Specification for Gray Iron Castings
2. ASTM C478 – Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
3. ASTM C923 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
4. ASTM C1244 – Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
5. Standard Specifications for Public Works Construction (SSPWC), “Greenbook”

1.04 SUBMITTALS

A. All submittals shall be submitted in accordance with Section 01300, “Shop Drawings and Submittals”.

B. Submit manufacturer’s catalog data on precast concrete manholes, frames, and covers. Show dimensions, reinforcing, concrete mix design and materials of construction by ASTM reference and grade. Show lettering on manhole covers.

C. Design calculations showing design for concrete member thicknesses and reinforcement.

D. Shop drawings shall show dimensions, locations, lifting inserts, reinforcement, and joints.

E. Submit manufacturer's data sheets on ductile iron pipe, joints, and fittings including dimensions, wall thickness, weight, coating, lining, and deflections at push-on and mechanical joints.

1.05 QUALITY ASSURANCE

A. After installation, the CONTRACTOR shall demonstrate that manholes have been properly installed, level, with tight joints, at the correct elevations and orientations, and that the backfilling has been carried out in accordance with the Contract Documents.

PART 2 - MATERIALS

2.01 MANHOLES

A. The CONTRACTOR shall provide precast manhole sections and conical sections conforming to ASTM C478 and the requirements of this Section. Adjusting rings shall be standard items from the manufacturer of the manhole sections. Minimum wall thickness of rings shall be 1/8 of the internal diameter of the riser or largest cone diameter.

B. Axial length of sections shall be selected to provide the correct total height with the fewest joints and shall be in accordance with the Standard Drawings.

C. Conical sections shall be designed to support cast iron frames and covers under an AASHTO HS-20 vehicle loading, unless indicated otherwise.

D. Sewer manhole sections shall be cast without ladder rungs.

E. Design Criteria: Manhole walls, transitions, conical sections, and base shall be designed per ASTM C478 for the depths indicated and the following:

1. AASHTO HS-20 vehicle loading applied to the cover.
2. Unit weight of soil of 120 pcf located above all buried portions of the manhole.
3. Lateral soil pressure based on saturated soil producing 100 pcf acting on an empty manhole.
4. Lateral soil pressure due to surcharge loading based on AASHTO HS-20 loading applied adjacent to the manhole.
5. Internal fluid pressure based on weight of 63 pcf with manhole filled from invert to cover with no balancing external soil pressure.
6. Dead load of manhole sections fully supported by the base and transition.
7. The minimum allowable steel shall be hoops of No. 4 wire. Add reinforcing steel in walls to transfer stresses at openings.

8. The minimum clear distance between the edges of any 2 wall penetrations shall be 12-inches or one-half of the diameter of the smaller penetration, whichever is greater.

9. All manholes on sewer pipelines, all drop manholes, regardless of size and all force main terminal manholes shall be coated with a lining system per specification section 09801, “Manhole Lining”.

F. Joint sealing compound shall be a butyl rubber sealant material in a flexible rope or rolled form with removable wrapper sized to fit into the key manhole sections.

1. Concrete for base and channel formation and precast concrete sections shall be concrete conforming to the Standard Specifications and shall meet the following minimum mix design requirements of SSPWC Section 201-1:All applications shall use a minimum of Class 560-C-3250 concrete, unless otherwise shown on the Drawings or as directed by the DISTRICT.

   a. Mix design requirements for 560-C-3250 concrete shall be in conformance with SSPWC Section 201-1.1.2.

   b. The maximum slump shall be 4" to 5”.

   c. The maximum water/cement ratio shall be 0.50 by weight.

2. All applications where concrete is anticipated to experience moderate or severe exposure to sulfates shall use the special exposure mixes of SSPWC Table 201-1.1.3.

   a. Moderate exposure applications shall conform to Special Exposure 658-CME-4500P.

   b. Severe exposure applications shall conform to Special Exposure 658-CSE-5000P.

   c. The maximum water/cement ratio for Special Exposure conditions shall be in conformance with SSPWC Table 201-1.1.3.

G. Refer to Standard Specification Section 03300 for additional concrete and reinforcing material requirements.

H. Repair mortar and an epoxy bonding agent shall be used to repair minor surface damage to precast sections or cast-in-place manhole bases at the discretion of the DISTRICT. Repair products shall be in accordance with Standard Specifications Section 03740.

I. Barrel section to sewer pipe connections shall be sealed with manhole stop rings complying with ASTM C923, not extruded, as manufactured Newby Rubber Inc., or approved equal.

J. Drop manholes, if approved by the DISTRICT, shall conform to the applicable provisions for precast manholes as specified herein.

K. An approved seal or waterstop shall be placed over the plastic sewer main at the manholes per DISTRICT standard drawings.

L. Manhole Manufacturers per the Approved Materials List.

2.02 MANHOLE FRAMES AND COVERS

A. Manhole frames shall be 36 inches in diameter with two concentric covers, made of cast-iron in accordance with ASTM A48 Class 30 and the Standard Drawings. Covers shall incorporate a "pic-hole" for lifting purposes.

1. Locking frames and covers may be required in areas located outside the public right of way, in remote areas or when determined by the DISTRICT.

B. Frames and covers shall be designed for HS-20 highway wheel loading.

1. Manhole frame and cover shall be per District Standard Drawing S-14 to S-15.

C. Covers shall be cast with the words "RINCON" and "SEWER". No other lettering will be permitted on the top portion of the cover.

D. Casting shall be smooth, clean, and free from blisters, blowholes, and shrinkage. Mating surfaces of the frame and cover shall be machined smooth and true to prevent rocking and lateral movement of the lid. Frames and covers shall be match marked in sets before shipping to the site.

E. All castings shall be dipped twice in a preparation of asphalt or coal tar and oil applied at a temperature of not less than 290 degrees F nor more than 310 degrees F and in such a manner as to form a firm and tenacious coating.

F. Castings Manufacturers per the Approved Materials List.

2.03 MANHOLE LINING

A. New manholes shall be lined in accordance with the specification Section 09801.

PART 3 - EXECUTION

3.01 GENERAL

A. Pre-cast concrete sections shall be transported and handled with care in accordance with the manufacturer's written recommendations. Where lifting devices are provided in pre-cast sections, such lifting devices shall be used as intended. Where no lifting devices are provided, the CONTRACTOR shall follow the manufacturer's recommendations for lifting procedures to provide proper support during lifting.

B. The manhole base shall be poured in place against a minimum of 6-inches of 3/4" crushed rock base situated on undisturbed soil. The manhole stubs and sewer main shall be set before the concrete is placed and shall be rechecked for alignment and grade before the concrete has set. The various sized inlets and outlets to the manhole shall be located as indicated on the Approved Plans. The manhole base shall extend 10 inches below the bottom of the lowest pipe. Invert elevations of connecting sewers may vary depending upon sizes. When intercepting flows from smaller pipelines in manholes, set invert of the smaller mains at ¾ of the depth of the larger main.

C. The invert of the manhole base shall be hard worked so as to provide channels conforming in size and shape to the lower portions of the inlets and outlets. The channel shall vary uniformly in size and shape from inlet to outlet and be constructed higher than pipe as indicated on the Approved Plans. The manhole invert channels shall be smooth and accurately shaped. Channels may be formed directly in the concrete base. All transitions shall be smooth and of the proper radius to give an uninterrupted transition of flow. The concrete base shall be shaped with a wood float and shall receive a hard-steel trowel finish prior to the concrete setting.

D. In the event additional mortar is required after initial set has taken place, the surface to receive the mortar shall be primed with Sika Armatec 1C or approved equal in the amounts and proportions recommended by the manufacturer. The bases shall set a minimum of 24 hours before the manhole construction is continued.

E. Straight through channels in manholes with no tributaries may have SDR 35 PVC pipe installed though the manhole. The top section of pipe shall be removed flush with top of shelf. All cuts shall be neat and dressed minimizing burrs and rough edges.

F. Each manhole section shall be sealed with butyl rubber sealant rope (see Standard Detail S-5) to make a watertight joint, shall be neatly banded on the inside and outside and shall be set plumb. All manholes shall be vacuum tested in accordance with the procedures specified herein in Paragraph 3.03 of this Section.

G. Sections of various height grade rings shall be used in order to bring the top of the manhole ring and cover to the elevation on the Approved Plans but limited to a maximum of 18 inches of grade ring. The precast concrete manhole rings shall be jointed with a minimum thickness of ½ inch of Portland cement mortar along with butyl rubber sealant rope. Mortar shall be composed of one part Portland cement to two parts clean well-graded sand of such size that all pass a No. 8 sieve. Preformed, cold applied ready-to-use plastic joint sealing compound may be substituted for mortar between units and shall be used when ground water is encountered.

H. The finished elevations at which the manhole frames and covers are to be set shall conform to the requirements set forth in the Approved Plans. Where the frame and cover are in existing pavement or in the traveled way of the existing road shoulder, it is to be placed flush with the existing surface. When the structure is outside the limits of the traveled shoulder but not in the roadside ditch, it should be placed 1/10-foot above the existing ground surface.

I. Where the manhole cover falls in the existing roadside ditch or easement right-of- way “offsite”, it is to be placed approximately 6-inches above the existing ground surface. Manhole frames shall be set at the required grade and shall be securely attached to the top precast manhole shaft unit with a cement-mortar bed and fillet. After the frames are securely set-in place, covers shall be installed and all necessary cleaning and scraping of foreign materials from the frames and cover shall be accomplished to ensure a satisfactory fit.

1. Damp-proof material shall be applied, when ground water is present or anticipated and at the discretion of the DISTRICT, to the exterior surfaces of manholes in accordance with the manufacturer’s recommendations. The material shall be applied to all exterior surfaces below a point one foot above the maximum water

table or indications of seepage or moisture as directed by the DISTRICT. Use water-proofing material for exterior surface when below ground water, or as required by DISTRICT.

2. Selected clean backfill material shall be used around all manholes and shall be non-reactive with concrete. It shall be compacted by pneumatic tampers unless shown otherwise on the Approved Plans.

3. A concrete ring shall be cast around manhole frames to within 3" of finished grade and capped with asphalt, as shown on the Approved Plans. The ring shall be placed after the final grading or paving together with the final cleanup.

3.02 WATER-TIGHTNESS OF MANHOLES

A. All manholes and appurtenances shall be watertight and free from infiltration. All manhole joints shall use butyl rubber sealant material to provide a watertight seal and shall comply with the vacuum test requirements specified herein in Paragraph 3.03 of this Section. Sections of manholes below ground water levels or anticipated ground water levels shall have sealant material installed on the external surface.

3.03 VACUUM TESTING OF MANHOLES

A. All sewer manholes shall be vacuum tested in accordance with the requirements specified herein and in accordance with ASTM C1244.

B. Vacuum testing equipment shall be as manufactured by P.A. Glazier, Inc. or approved equal.

C. Manholes shall be tested after assembly and prior to mortaring the joints or backfilling. In case of manholes incorporating a PVC liner, the testing is to take place prior to mortaring the joints, welding the liner seams between sections, and backfilling.

D. All lift holes shall be plugged with an approved grout prior to testing. All pipes entering the manhole shall be plugged and bracing installed to prevent the plug from being drawn into the manhole. The test head shall be placed inside the top of the cone section and the seal inflated in accordance with the manufacture's recommendations. A vacuum of 10 inches of mercury shall be drawn. The time shall be measured for the vacuum to drop 9-inches. The manhole shall pass the test if the time taken for the drop is greater than 60 seconds. If the manhole fails the test, necessary repairs shall be made, and the test repeated until acceptable results are obtained. The leak(s) shall be located and repaired, according to the type of leak, with material in-kind.

3.04 PULL TESTING OF PVC LINED MANHOLES

A. PVC lined manholes shall have field-welded joints pull tested. Field welds shall withstand a pull test of at least 100 lbs per linear inch, applied perpendicularly to the concrete surface for a period of one minute, without evidence of cracks or separations. This test shall be conducted at a temperature of 70°F to 80°F inclusive.

3.05 HOLIDAY TESTING OF PVC LINED AND POLYURETHANE COATED MANHOLES

A. PVC lined and Polyurethane coated surfaces shall be holiday tested with an electrical holiday detector as manufactured by Tinker and Rasor (Model # AP-W with power pack) or approved equal with the instrument set at 20,000 volts and used as directed by the DISTRICT's. All imperfections identified on the PVC lining or polyurethane coating shall be repaired with materials-in-kind and the test shall be repeated until no holidays are evident.

END OF SECTION