SECTION 03100
CONCRETE FORMWORK

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install the concrete formwork as required by the concrete outlines shown and indicated on the Drawings and specified in this Section, complete. The use of stay in place forms is expressly prohibited.

B. Coordination: Notify other contractors in advance of the trades of the formwork to provide the other trades with sufficient time for the installation of items included in their contracts that must be installed with the formwork.

C. Form Design: Formwork shall comply with ANSI A10.9 and OSHA Construction Standards, Part 1926, Subpart Q, Concrete, Concrete Forms, and Shoring. In addition, the form designs shall meet the requirements of ACI 347.

1.02 SUBMITTALS

A. Submit for approval copies of manufacturer's data and installation instructions for proprietary materials, including form coatings and releasing agents, manufactured form systems, ties and accessories.

B. Do not provide submittals for the structural design of forms.

1.03 QUALITY ASSURANCE

A. Allowable Tolerances:

1. Construct formwork to provide completed concrete surfaces complying with tolerances specified in ACI 347.
2. Maximum acceptable deflection is 1/8" in 5'-0" on all flat surfaces (ACI 347 Class A Finish).

B. Notify the Engineer a minimum of 48 hours before closure of forms that would hinder the subsequent inspection to enable the Engineer to inspect the work.

1.04 PRODUCT DELIVERY. STORAGE AND HANDLING

A. On delivery to jobsite, place materials in area protected from weather.

B. Store materials above ground on framework or blocking. Cover wood for forms with protective waterproof covering. Provide for adequate air circulation or ventilation.

C. Handle materials to prevent damage.

PART 2 - PRODUCTS

2.01 FORM MATERIALS

A. Forms for Exposed Finish Concrete: (Smooth Finish)

1. Unless otherwise shown or specified, construct formwork for concrete surfaces exposed to view in the finished structure, with plywood, metal, metal-framed plywood-faced or other panel type materials acceptable to Engineer, to provide continuous, straight, smooth as-cast surfaces.

2. Furnish in largest practical sizes to minimize number of joints and to conform to joint system shown or specified. Provide form material with sufficient thickness to withstand pressure of newly placed concrete without bow or deflection.

B. Forms for Unexposed Finish Concrete: (Rough Finish)

1. Form concrete surfaces that will be unexposed in the finished structure with plywood, lumber, metal, or other acceptable material. Provide lumber that is dressed on at least 2 edges and 1 side.

C. Form Ties

1. Provide factory-fabricated, removable or snap off metal form ties designed to prevent form deflection, and to prevent spalling of concrete surfaces upon removal. Materials used for tying Forms will be subject to approval of the Engineer.

2. Unless otherwise shown, provide ties so that portion remaining within concrete after removal of exterior parts is at least 1 inch from the outer concrete surface. Unless otherwise shown, provide form ties that will leave a hole no larger than 1-inch diameter in the concrete surface.

3. Ties for exterior walls and walls subject to hydrostatic pressure shall have waterstops that are integral with the tie, preferably a solid washer at mid-point of the tie.

4. Provide wood or plastic cones for ties, where concrete is exposed in the finished structure.

D. Forms Coatings: Provide commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion, nor impede the wetting of surfaces to be cured with water or curing compounds.

PART 3 - EXECUTION

3.01 DESIGN OF FORMWORK

A. Formwork shall be in accordance with ACI 347 and as follows:

1. Design, erect, support, brace and maintain formwork so that it shall safely support vertical and lateral loads that might be applied, until such loads can be supported by the concrete structure. Carry vertical and lateral loads to ground by formwork system or in-place

construction that has attained adequate strength for this purpose. Construct formwork so that concrete members and structures are of correct size, shape, alignment, elevation and position.

2. Design forms and falsework to include make full allowance for all of live loads, dead loads, weight of moving equipment operated on formwork, concrete mix, height of concrete drop, vibrator frequency, ambient temperature, foundation pressures, stresses, lateral stability, and other factors pertinent to safety of structure during construction.
3. Forms shall conform to shape, lines and dimensions of members indicated and shall be sufficiently rigid and tight to prevent leakage of mortar. Forms shall be properly braced or tied together so as to maintain position and shape. Construct forms so that they can be removed readily without hammering or prying against the concrete. Forms shall be carefully made and accurately placed to obtain correct shape and lines.
4. Joints shall be butted tight. Arrangements of panels shall be orderly and symmetrical, and use of small pieces shall be avoided. Forms shall be chamfered 1-inch for external corners of concrete, including tops of walls, which will be exposed to view in the finished work.
5. Provide adequate formwork in its entirety. Forms shall safely support loads they will sustain and shall maintain their dimensional and surface correctness to produce members required by the Drawings. Form ties shall be spaced close enough to avoid bulges and variations in the required cross-sectional dimensions shown on the Drawings for the members being cast.
6. Box out for chases, recesses or other openings required in the completed work.
7. Install all the items (sleeves, inserts, hangers, anchors, etc.), to be supported by the formwork as required by the work.
8. Install pipe sleeves, wall pipes and wall sleeves, as shown or specified, for all piping penetrating walls and slabs. The use of block-outs in walls is prohibited.
9. Provide a sufficient number of cleanout doors at the base of walls and columns to facilitate cleaning and the application of grout to the base of walls.
10. The use of reinforcing steel, partially embedded in concrete, as toe pins or form spacers is prohibited.

B. Forms for Exposed Concrete

1. Do not use metal cover plates for patching holes or defects in forms.
2. Provide sharp, clean corners at intersecting planes, without visible edges of offsets. Back joints with extra beams or girts to maintain true, square intersections.
3. Use extra beams walers and bracing to prevent bowing of forms between beams and to avoid bowed appearance in concrete. Do not use narrow strips of form material that will produce bow.
4. Assemble forms so they may be readily removed without damage to exposed concrete surfaces.
5. Form molding shapes, recessed and projections with smooth-finish materials, and install in forms with sealed joints to prevent displacement.
6. Chamfer exposed corners and edges.

C. Corner Treatment

1. Form exposed corners of beams, walls, bases and columns to produce smooth, solid, unbroken lines, except as otherwise shown. Except as specified below for re-entrant or internal corners, exposed corners shall be chamfered.

2. Form chamfers with ¾ by ¾ strips, unless otherwise shown, accurately formed and surfaced to produce uniformly straight lines and tight edge joints. Extend terminal edges to required limit and miter chamfer strips at changes in direction.

3. Re-entrant or internal corners and unexposed corners may be formed square.

D. Joints: See Specification Section 03250 and Drawings for treatment of joints. Locate as shown and specified.

E. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris just before concrete is to be placed. Re-tighten forms immediately after concrete placement as required to- eliminate mortar leaks.

3.02 FORM COATINGS

A. Coat form contact surfaces with a non-staining no petroleum form coating compound before reinforcement is placed. Do not allow excess form coating material to accumulate in the forms or to come into contact with surfaces, which will be bonded to fresh concrete. Apply in compliance with manufacturer's instructions.

B. Volatile organic compound emissions of form releasing agents shall not exceed 2.09 pounds per gallon or that as acceptable in the state, county, or district of their intended use, whichever is more stringent.

C. Coat steel forms with a non-staining, rust-preventative form oil or otherwise protect against rusting. Rust-stained steel formwork is not acceptable.

1. Form releasing agents must not impair subsequent treatment of concrete surfaces that depend upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds.

3.03 INSTALLATION OF EMBEDDED ITEMS

A. General

1. Set and build into the formwork, anchorage devices and other embedded items, shown specified or required by other Section. Refer to paragraph 1.01 herein for the requirements of coordination. Use necessary setting drawings, diagrams, instructions and directions.

2. All embeds should be supported, plumbed and carefully taped or covered to prohibit the infiltration of concrete during the pour.

3. Coat any aluminum or reactive metal inserts, with non-reactive coating to isolate the metal surfaces.

B. Edge Forms and Screed Strips for Slabs and Sidewalks

1. Set edge forms or bulkheads and intermediate screed strips for slabs and sidewalks to obtain required elevations and contours in the finished slab surface. Provide and secure units to support screeds.

2. The screeds may not be tack welded to the rebar embeds, or structural steel.

3.04 FIELD QUALITY CONTROL

A. Before concrete placement, the Engineer shall inspect all formwork. No concrete shall be poured without Engineer approval.

B. Before concrete placement, Contractor shall check the formwork, including lines, ties, tie cone, and form coatings. Contractor shall make corrections and adjustments to ensure proper size and location of concrete members and stability of forming systems.

C. During concrete placement Contractor shall check formwork and related supports to ensure that forms are not displaced and that completed Work shall be within specified tolerances.

D. If Contractor finds that forms are unsatisfactory in any way, either before or during placing of concrete, placement of concrete shall be postponed or stopped until the defects have been corrected, and reviewed by the Engineer.

3.05 REMOVAL OF FORMS

A. Remove forms and falsework in a manner that will prevent damage to the concrete and not impair the safety of the structure.

B. Do not use pinch bars or similar tools to pry against concrete surfaces.

C. Do not remove forms until concrete has aged as follows:

1. Elevated slabs and beams: 7 days minimum.

2. Grade beams, columns, walls, construction and expansion joint bulkheads and other vertical surfaces: 24 hours minimum.

D. Elevated slabs and beams shall have attained at least 70 percent of the specified 28 day strength before form removal. Concrete shall also have sufficient strength to safely support its own weight and construction loads. Determine concrete strength for form removal in conformance with ACI 301.

E. Reshore elevated concrete elements immediately upon form removal. Shoring shall remain in place until the concrete has attained the specified 28 day design strength.

F. Maintain shoring of elevated concrete elements which support subsequent construction when the subsequent construction loads exceed the design live load of the elements

3.06 REUSE OF FORMS

A. Clean and repair surfaces of forms to be re-used in the Work. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable. Apply new form coating compound material to concrete contact surfaces as specified for new formwork.

1. Plywood surfaced forms must have smooth clean faces for re-use, and may not have excessive knots or tie hole plugs. They may not be used more than 3 times without an Engineer's inspection and approval.

2. Metal surfaced forms must have a smooth even surface without plate patches.

END OF SECTION 03100

SECTION 03200
CONCRETE REINFORCEMENT AND DOWELLING

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install the concrete reinforcement as shown and indicated on the Drawings and specified in this Section, complete in place.

B. Provide and set reinforcement and accessories for electrical work as indicated and specified under electrical work.

C. Provide reinforcing bar dowels to be embedded into concrete elements at top and bottom of CMU walls as indicated and specified. Furnish wall reinforcement for concrete masonry walls for installation.

1.02 SUBMITTALS

A. Shop Drawings

1. All shop drawings shall be of the same size. Reproductions of the Drawings for use as shop drawings are not permitted. Shop drawings shall include placing drawings, bending details, and bar lists with bar marks. All details and notes appearing on the Drawings, giving information for the placing of reinforcing steel, shall be shown on the shop drawings. Shop drawings will not be reviewed without such information.
2. Wall reinforcing shall be shown in elevation.
3. Show location and size of all penetrations greater than 6-inches in diameter or across the opening with the corresponding added reinforcing around the penetrations.
4. Location and arrangement of accessories shall be clearly indicated.
5. All shop drawings shall be checked by the fabricator and Contractor before being submitted to the Engineer.

B. Mill tests of reinforcing steel shall be submitted prior to use for each 15 tons or less shipped to the site. Tests shall be conducted in conformance with ASTM A615, and methods prescribed herein.

1. Cost of mill tests shall be borne by Contractor.
2. Three copies of each test report stating whether the material meets the requirements of the ASTM specifications shall be submitted to the Engineer.
3. Certified copies of the mill tests may be considered evidence of compliance provided such tests are regularly conducted by the reinforcement supplier by experienced, competent personnel using adequate testing equipment. In case of doubt as to the adequacy or accuracy of the mill tests, the Engineer may require the Contractor to furnish, at no additional cost to the Owner, test results from an independent testing laboratory acceptable to the Engineer on mill samples or delivered steel reinforcement.

1.03 QUALITY ASSURANCE

A. Minimum Concrete Cover for Reinforcement: Comply with ACI 350, except as shown on Drawings

B. Splices other than lap splices shall not be used except where permitted in writing by the Engineer.

C. Field bending of reinforcement is prohibited unless reinforcement is indicated or specified to be field bent.

1.04 DELIVERY, STORAGE AND HANDLING

A. Deliver concrete reinforcement materials to the site bundled, tagged and marked. Use metal tags indicating bar size, length, and other information corresponding to markings shown on placement diagrams. Reinforcement which arrives on the jobsite which is not tagged shall be rejected by the Engineer.

B. Store concrete reinforcement material at the site to prevent damage and accumulation of dirt or excessive rust. Store on heavy wood blocking so that no part of it will come in contact with the ground.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Reinforcing Bars and Dowelling shall conform to ASTM A 615, Grade 60.

B. Steel Wire: Shall conform to ASTM A82.

C. Welded Smooth Wire Fabric: Shall conform to ASTM A185:

1. Furnish in flat sheets, not rolls.

D. Supports for Reinforcement: Bar supports coming into contact with forms shall be CRSI Class 1 plastic protected or Class 2 stainless steel protected and shall be located in accordance with CRSI MSP-1 and placed in accordance with CRSI PRB. Precast concrete block supports shall be provided for reinforcing in concrete cast against grade.

2.02 FABRICATION

A. General: Fabricate reinforcing bars to conform to required shapes and dimensions, with fabrication tolerances complying with CRSI "Manual of Standard Practice" and ACI minimums. In case of fabricating errors, do not re-bend, retemper, heat, deform or straighten reinforcement.

B. Unacceptable Materials: Reinforcement with any of the defects listed below will not be permitted in the Work:

1. Bar lengths, bends, and other dimensions exceeding specified fabrication tolerances.
2. Bends or kinks not shown on approved Shop Drawings.
3. Bars with reduced cross-section due to excessive rusting or other cause.

4. Surface contamination that would affect the bond i.e., grease, dirt, paint, rust etc.

5. Heat deformed or torched bars.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with the applicable recommendations of specified codes and standards, and CRSI "Placing Reinforcing Bars" and ACI requirements for details and methods of reinforcement placement and supports.

B. Clean reinforcement to remove loose rust and mill scale, earth, ice, and other materials, which reduce or destroy bond with concrete.

C. Position, support, and secure reinforcement and dowelling against displacement during formwork construction or concrete placement and grouting operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers and hangers, as required. No wood blocks allowed for rebar support.

1. Place reinforcement to obtain the minimum concrete coverages as shown and as specified in ACI 350. Arrange, space, and securely tie bars and bar supports together with 16 gauge wire to hold reinforcement accurately in position during concrete placement operations. Set wire ties so that twisted ends are directed away from exposed concrete surfaces.

2. Reinforcing steel shall not be secured to forms with wire, nails or other ferrous metal. Metal supports subject to corrosion shall not touch formed or exposed concrete surfaces.

D. Install welded wire fabric in as long lengths as practical. Lap adjoining pieces at least one full mesh and lace splices with 16 gauge wire and tie.

E. Provide sufficient numbers of supports of strength required to carry reinforcement without sagging. Do not place reinforcing bars more than 2 inches beyond the last leg of any continuous bar support. Do not use supports as bases for runways for concrete conveying equipment and similar construction loads.

F. Splices: Provide standard reinforcement splices by lapping ends, placing bars in contact, and tying tightly with wire. Comply with requirements shown for minimum lap of spliced bars.

G. Existing concrete, which is shown to remain but is removed in error or must be removed to install new Work, and then to be reinstalled is to be reinforced to the extent as required and approved by the Engineer. This work will be performed with no additional compensation to the Contractor.

H. Do not straighten or rebend reinforcing.

I. Reinforcement Around Openings: Place an equivalent area of steel around the pipe or openings and extend on each side sufficiently to develop bond in each bar. See the Details on the Drawings for bar extension length each side of openings. Where welded wire fabric is used, provide extra reinforcing using fabric or deformed bars.

J. Welded Reinforcement: Welding is not permitted.

3.02 INSPECTION OF REINFORCEMENT

A. After the rebar, appliance, anchors and embedments have been installed and checked, the Contractor shall review all aspects of the pending concrete pour and initial those items on its pour card. Contractor shall notify the Engineer no less than 24 hours prior to the pour, so that the Engineer may check the area to be poured. No concrete shall be placed until this is complete.

B. Concrete shall not be placed until the reinforcing steel is inspected and permission for placing concrete is granted by the Engineer. All concrete placed in violation of this provision will be rejected. Rejected concrete shall be removed and replaced at no cost to the City.

END OF SECTION 03200

SECTION 03250
CONCRETE ACCESSORIES

PART 1 - GENERAL

1.01 SCOPE

A. The work covered by Section includes, but is not necessarily limited to, furnishing and installing all concrete accessories as indicated on the Drawings, herein specified, and as necessary for the progress and complete performance of this work.

1.02 SUBMITTALS

A. The waterstop manufacturer shall submit documented test results demonstrating that the waterstop will not permit water leakage when subjected to pressure and joint movement.

1.03 QUALITY ASSURANCE

A. The waterstop manufacturer shall demonstrate five years (minimum) continuous, successful experience in production of waterstops.

1.04 STORAGE AND PROTECTION

A. Store waterstops under tarps to protect from oil, dirt, water, and sunlight.

1.05 QUALITY CONTROL

A. Contractor shall establish and maintain records sufficient to furnish evidence of quality of materials, equipment, storage, and workmanship.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Waterstops for construction joints shall be Wirestop Waterstop Type No. FR-6380 manufactured by Paul Murphey Plastics Company, Rossville, Michigan; Vinylex Waterstop Type R6-38T manufactured by Vinylex Corporation, Knoxville, Tennessee; or Greenstreak Waterstop Stop 679 manufactured by Greenstreak, St. Louis, Missouri.

B. Expanding waterstops for construction joints shall be Hydrotite Waterstop Profile CJ-0725 manufactured by Greenstreak, St. Louis, Missouri or equal.

2.02 MATERIALS AND CONSTRUCTION

A. Waterstops

1. Waterstops shall be extruded from an elastomeric plastic compound of which the basic resin shall be prime virgin polyvinyl chloride meeting U.S. Army Corps of Engineers Specification CRD-C572-74. The PVC compound shall not contain any scrapped or reclaimed material or pigment whatsoever.

2. Provide factory installed hog rings, grommets, or embedded wire loop to facilitate tying off waterstop at 12-inches on center along the length of the waterstop.

3. Provide factory made PVC waterstop fabrications for all changes of direction, intersections and transitions, leaving only straight butt joint splices for the field.

4. Expanding waterstops shall be coextruded hydrophilic rubber consisting of a combination of chloroprene rubber and chloroprene rubber modified to impart hydrophilic properties.

5. Expanding waterstops shall have a delay coating to inhibit initial expansion due to moisture present in fresh concrete.

6. Minimum profile dimensions of expanding waterstop shall be 1/4 x 1-inch.

B. Dovetail Slots

1. No. 22 gauge, galvanized steel, 1-inch wide back.

2. Crimped anchors shall be furnished by other trades whose work abuts concrete.

C. Inserts for General Trades

1. Malleable iron, strength as required.

2. Include bolts, nuts, and washers.

2.03 OTHER MATERIALS

A. All other materials not specifically described, but required for a complete and proper installation of concrete accessories, shall be as selected by the Contractor subject to the approval of the Engineer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Install concrete accessories as indicated on the Drawings, specified in various other Sections and as necessary for the proper and complete performance of this work.

B. Waterstops

1. Waterstops shall be installed in all construction joints in walls and slabs which are to hold water and also where shown on the Drawings. The waterstop shall extend the entire length of the joint and all splices shall be installed and tested in accordance with the manufacturer's recommendations. Place waterstop to form a continuous watertight diaphragm in joints.

2. Waterstops for all joints shall be continuous around all corners and intersections. For PVC waterstops, provide factory formed corners and intersections where angle intersections occur, and only straight splices shall be made in the field. Splices shall be made in accordance with the manufacturer's recommendations and shall be subject to the approval of the Engineer. Maintain 2-in. [50 mm] minimum clearance between waterstop and reinforcement and embedded items.

3. No holes will be permitted in waterstops.

4. Waterstops shall be securely fastened to formwork or reinforcing steel every 12-inches or less on both edges as required to concrete placement.
5. Expanding waterstops shall be spliced using cyanoacrylate adhesive (super glue) and a band-aid seal of hydrophilic polyurethane sealant.
6. Cut coil ends of expanding waterstops square (or at proper angle for mitered corners) with shears or sharp blade to fit splices together without overlaps.
7. Joinery between PVC and expanding waterstops shall be sealed using hydrophilic polyurethane sealant.
8. Provide concrete surface preparation that is consistent with the manufacturer's recommendations for expanding waterstops. Coordinate this preparation with other joint preparation shown on the drawings.
9. Install the expanding waterstop in accordance with the manufacturer's recommendations.

END OF SECTION 03250

SECTION 03300
CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install the cast-in-place concrete as shown and indicated on the Drawings and as specified in this Section, complete.

B. Coordination:

1. Review installation procedures under other Sections and coordinate the installation of items that must be installed in the concrete.
2. Notify other trades in advance of the placing of concrete to provide the other trades with sufficient time for furnishing of items included in their work that must be installed in the concrete.
3. Required City formal pour card with all required signatures.

C. The following classes of concrete are required. Refer to the Drawings for their locations.

1. Class A
2. Class D
3. Class G

1.02 SUBMITTALS

A. Submit for approval the following:

1. List of concrete materials and concrete mix designs proposed for use. Include the results of all tests performed to qualify the materials and to establish the mix designs.
2. Copies of manufacturer's specifications with application and installation instructions for proprietary materials and items, including admixtures and bonding agents.

B. Laboratory Test Reports: Submit copies of laboratory test reports for concrete cylinders, materials and mix design tests. Production of concrete to comply with specified requirements is the responsibility of the Contractor. Submit the testing lab's average strength curve from the design mix proportions of the approved materials.

C. Submit certification of conformance to referenced standards to the Engineer and a copy of the batch plant's most recent scale calibration.

D. Delivery Tickets: Furnish to Engineer copies of all delivery tickets for each load of concrete delivered to the site. Provide items of information as specified in ASTM C 94, Section 14.

1.03 QUALITY ASSURANCE

A. Reference Standards: Comply with the applicable provisions and recommendations of the latest edition following, except as otherwise shown or specified:

1. ACI 301, Specification for Structural Concrete for Buildings, (includes ASTM Standards referred to herein).
2. ACI 304, Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete.
3. ACI 305, Recommended Practice for Hot Weather Concreting.
4. ACI 306, Recommended Practice for Cold Weather Concreting.
5. ACI 308, Standard Practice for Curing Concrete.
6. ACI 309, Recommended Practice for Consolidation of Concrete.
7. ACI 318, Building Code Requirements for Reinforced Concrete.
8. ACI 347, Recommended Practice for Concrete Formwork.
9. ACI 350, Code Requirements for Environmental Engineering Concrete Structures
10. ASTM C31, Standard Method of Making and Curing Concrete Test Specimens in the Field.
11. ASTM C33, Standard Specification for Concrete Aggregates.
12. ASTM C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
13. ASTM C40, Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
14. ASTM C42, Standard Methods of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
15. ASTM C94, Standard Specification for Ready-Mixed Concrete.
16. ASTM C138, Standard Test Method for Unit Weight, Yield and Air Content (Gravimetric) of Concrete.
17. ASTM C143, Standard Test Method for Slump of Portland Cement Concrete.
18. ASTM C150, Standard for Portland Cement.
19. ASTM C157, Standard Test Method for Length Change of Hardened Cement Mortar and Concrete
20. ASTM C171, (1986) Standard Specification for Sheet Materials for Curing Compounds.
21. ASTM C172, Standard Method of Sampling Freshly Mixed Concrete.
22. ASTM C173, Standard Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
23. ASTM C192, Standard Method of Making and Curing Concrete Test Specimens in the Laboratory.
24. ASTM C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
25. ASTM C260, Standard Specification for Air-Entraining Admixtures for Concrete.
26. ASTM C494, Standard Specification for Chemical Admixtures for Concrete.
27. ASTM C827, Standard Test Method for Early Volume Change of Cementitious Mixtures.
28. Federal Specification CCC-C-467C: Cloth, Burlap Jute or Kenaf.

B. Concrete Testing Service

1. By Contractor's Testing Laboratory:
   a. Contractor shall employ, at its own expense, a testing laboratory, approved by the Engineer and experienced in design and testing of concrete materials and mixes to perform material evaluation tests and to design concrete mixes.
      i) Testing agency shall meet the requirements of ASTM E 329.
      ii) Submit a written description of the proposed concrete testing laboratory giving qualifications of personnel, laboratory facilities and equipment, and other information, which may be requested by the Engineer.
      iii) Submit certification that the testing laboratory meets the requirements of ASTM E329.
   b. Materials and installed Work may require testing and retesting, as directed by the Engineer, at any time during the progress of the Work. Allow free access to material stockpiles and facilities at all times. Tests not specifically indicated to be done at the City's expense, including the retesting of rejected materials and installed Work, shall be done at the Contractor's expense.
2. By Independent Testing Laboratory: Testing for concrete field quality control as specified under Paragraph 3.14 of this Specification, shall be performed by an independent testing laboratory approved by the Engineer. The cost of all concrete testing for field quality control shall be paid for by the Contractor and shall be included in the Contractor's base bid. The Contractor shall be responsible for notifying the independent testing laboratory to schedule the testing as specified.

C. Test for Concrete Materials: Submit written reports to the Engineer, for each material selected and tested, prior to the start of Work. Provide the Project identification name and number, date of report, name of Contractor, name of concrete testing service, source of concrete aggregates, material manufacturer and brand name for manufactured materials, values specified in the referenced Specification for each materials, and test results. Indicate acceptability of materials for intended use.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING

A. All materials used for concrete must be kept clean and free from all foreign matter during transportation and handling and kept separate until measured and placed in the mixer. Bins or platforms having hard clean surfaces shall be provided for storage. Suitable means shall be taken during hauling, piling and handling to ensure that segregation of the coarse and fine aggregate particles does not occur and the grading is not affected.

PART 2 - PRODUCTS

2.01 CONCRETE MATERIALS

A. Cement

1. Portland cement, ASTM C 150, Type II.
2. Do not use cement which has deteriorated because of improper storage, handling or for any other reason.

B. Aggregates: ASTM C 33 and as herein specified.

1. Do not use aggregates containing soluble salts or other substances such as iron sulfides, pyrite, marcasite, ochre, or other materials that can cause stains on exposed concrete surfaces. Slag materials are not allowed.
2. Fine Aggregate: Clean, sharp, natural sand free from loam, clay, lumps or other deleterious substances.
   a. Dune sand, bank run sand and manufactured sand are not acceptable.
3. Coarse Aggregate: Clean granitic, uncoated, processed aggregate containing no clay, mud, loam, or foreign matter.

C. Water: Clean, free from injurious amounts of oils, acids, alkalis, potable, organic materials or other substances that may be deleterious to concrete or steel.

2.02 CONCRETE ADMIXTURES

A. Provide admixtures produced by established reputable manufacturers, and use in compliance with the manufacturer's printed instruction. Do not use admixtures, which have not been incorporated and tested in the accepted mixes, unless otherwise authorized in writing by the Engineer.

B. Water-Reducing Admixture: ASTM C 494, Type A.

C. Air entraining admixture shall conform to ASTM C 260.

D. Fly ash shall conform to ASTM C 618, Type F.

E. High range water reducer (HRWR) shall conform to ASTM C 494, Type G.

F. Calcium Chloride: Do not use calcium chloride in concrete.

G. Silica fume shall conform to ASTM C 1240.

2.03 PROPORTIONING AND DESIGN OF MIXES

A. The following classes of concrete are required.

Class of Concrete	Compressive Strength @ 28 Days	Slump Range Before HRWR	Slump Range After HRWR	Maximum W/C Ratio	Coarse Aggregate Size
A	4,000	1" – 2"	6" – 9"	0.45	57
D	4,000	1" – 2"	6" – 9"	0.42	67
G	3,000	1" – 4"	N/A	0.55	57

1. Fly ash is required in Classes A, and D concretes. The fly ash shall not exceed more than 20% of combined weight of fly ash and cement. The fly ash shall not be less than 15% of the combined weight of fly ash and cement. The combined weight of cement and fly ash shall be used as the weight of cement in the determining of the water-cement (w/c) ratio.
2. Fly ash and Silica Fume are required in Class C concrete. The combined weight of the cement, fly ash and silica fume shall contain no less than 15 percent fly ash and no less than

10 percent silica fume. The combined weight of cement, fly ash and silica fume shall be used as the weight of cement in determining the water cement (w/c ratio).

3. Slump tests shall be made prior to adding the HRWR. The HRWR shall be added to the concrete at the batch plant. The slump range required after the addition of the HRWR is indicated in the table above. HRWR shall be capable of maintaining the required slump in excess of 60 minutes of continuous mixing at 4 to 6 rpm in a truck mixer and workability up to 90 minutes. Upon 72 hours notice, the HRWR manufacturer shall supply jobsite technical service to the Contractor. The manufacturer shall be consulted for mix proportions and dosage rates. The initial set shall not be in excess of six hours at temperatures above 50 degrees F. HRWR shall be used with due consideration given to the air temperature at the time of batching and casting.
4. If field experience method is used to select concrete mixes, the proposed mix designs shall be accompanied by complete standard deviation analysis and at least 20 consecutive strength test that represent the proposed mix.
5. The proposed mix design and supporting data shall be submitted, in triplicate, to the Engineer at least 30 days prior to the expected start of concreting operations.
6. Compression test specimens made to verify the mixes shall be made in accordance with ASTM C 192. All compression test specimens shall be tested in accordance with ASTM C 39.
7. Adjustment to Concrete Mixes During Construction: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to the Owner and as accepted by Engineer. Laboratory test data for revised mix designs and strength results must be submitted to the Engineer for acceptance before using the revised mixes.
8. Mix design shall be proportioned in accordance with ACI 211.1 making maximum use of the coarse aggregate. The proportioning shall be based on the requirements of a well-graded high density plastic workable mix within the slump range and strengths required. The mix shall be based on conventional conveying and shall not be altered for use in pumping. Pumping equipment, if used, shall be of sufficient size and design to pump the mix designed for conventional conveyance.
9. Submit samples, in adequate quantities for each mix design and verification, of all concrete materials to be used on the Project to the Contractor's testing laboratory. Do not use any concrete in this work without acceptance and verification of design mix by the Contractor's testing laboratory and the approval of the Engineer.
10. If Laboratory trial batches are used to select concrete mixes, the Contractor's testing laboratory shall make strength tests from trial batches in the laboratory using materials and mix designs proposed for use by the Contractor. The Contractor's testing laboratory shall prepare trial batches in accordance with ACI 211.1.
11. Class D concrete shall have an air content of 6% ± 1½%.
12. Class A concrete shall have 5 + 1% air content.
13. Class B concrete shall have 5 + 1% air content.

2.04 CHEMICAL HARDENER

A. Unless otherwise specified, all interior concrete floors of electrical and valve rooms shall be treated with a liquid hardener composed of magnesium and zinc fluorosilicates combined with an

anionic surfactant for improved wetting penetration. Liquid hardener shall be colorless, nontoxic, nonflammable, and compatible with and providing good adhesion for subsequent toppings and/or coatings. Liquid hardener shall be suitable for use on new or old concrete floors. Chemical hardener shall be FLUOHARD or Equal.

2.05 CONCRETE CURING MATERIALS

A. Absorptive Cover: Burlap cloth made from jute of kenaf, weighing approximately 10 ounces per square yard and complying with AASHTO M 182, Class 3.

B. Moisture-Retaining Cover: One of the following, complying with ASTM C 171.

1. Waterproof paper.
2. 4 mil polyethylene.

C. Curing and Sealing Compound: ASTM C-309.

PART 3 - EXECUTION

3.01 CONCRETE MIXING

A. General

1. Mixing plants shall comply with ASTM C 94 and shall have sufficient capacity to produce concrete of the qualities specified, in quantities required to meet construction schedule. All plant facilities are subject to inspection by the Independent Testing Laboratory and acceptance of the Engineer.
2. Mixing:
   a. Mix concrete with an approved rotating type batch machine.
   b. Remove hardened accumulations of cement and concrete frequently from drum and blades to assure acceptable mixing action.
   c. Replace mixer blades when they have lost 10 percent of their original height.
   d. Plant equipment and facilities: Conform to National Ready Mix Concrete Association "Plant and Delivery Equipment Specification".
   e. Mix concrete in revolving type truck mixers, which are in good condition and which produce thoroughly mixed concrete of the specified consistency and strength.
   f. Do not exceed the proper capacity of the mixer.
   g. Mix concrete for a minimum of two minutes after arrival at the job site, or as recommended by the mixer manufacturer.
   h. Do not allow the drum to sit while in transit.
   i. Mix at proper speed until concrete is discharged.
   j. Maintain equipment in proper operating condition, with drums cleaned before charging each batch. Schedule rates of delivery in order to prevent delay of placing the concrete after mixing, or holding dry-mixed materials too long in the mixer before the addition of water and admixtures.
   k. The Contractor shall ensure that the silica fume is uniformly dispersed throughout the concrete in accordance with mixing procedures recommended by the silica fume supplier.

3.02 TRANSPORTING CONCRETE

A. Transport and place concrete not more than 90 minutes after water has been added to the dry ingredients, except as noted in Section 02425.

B. Take care to avoid spilling and separation of the mixture during transportation.

C. Do not place concrete in which the ingredients have been separated.

D. Do not retemper partially set concrete, and do not add any water at the jobsite.

E. Use suitable and approved equipment for transporting concrete from mixer to forms.

3.03 CONCRETE PLACEMENT

A. Inspection of Work Before Placing Concrete

1. Inspect the area to receive concrete for any deficiencies, which would prevent proper placing of concrete. Do not proceed with placing concrete until such deficiencies are corrected.
2. Do not place in the concrete any item that is not required to be in the concrete by the Drawings and Specifications. Insert all the items shown on the Drawings or specified properly positioned and secured. Openings other than those, which are facilitated by sleeves shall be properly formed and positioned only after approval of the Engineer.
3. Remove hardened, or partially hardened, concrete on forms or reinforcement before placing concrete.
4. Do not place concrete on earth until the fill or excavation has been prepared as set forth under applicable sections of the Specifications for that work.

B. Place concrete continuously so that no concrete will be placed on concrete, which has hardened sufficiently to cause the formation of seams or planes of weakness within the section. Deposit concrete as nearly as practical in its final location to avoid segregation due to rehandling or flowing. Do not subject concrete to any procedure, which will cause segregation.

1. Screed concrete, which is to receive other construction to the proper level to avoid excessive skimming or grouting.
2. Do not use concrete which becomes non-plastic and unworkable, or does not meet the required quality control limits, or which has been contaminated by foreign materials. Do not use retempered concrete. Remove rejected concrete from the job site and dispose of it in an acceptable location.
3. Do not place concrete until all forms, bracing, reinforcement, and embedded items are in final and position and secure.
4. Unless otherwise approved, place concrete only when Engineer is present.

C. Concrete Conveying

1. Handle concrete from the point of delivery and transfer to the concrete conveying equipment and to the locations of final deposit as rapidly as practical by methods, which will prevent segregation and loss of concrete mix materials.

2. Provide mechanical equipment for conveying concrete to ensure a continuous flow of concrete at the delivery end. Provide runways for wheeled concrete conveying equipment from the concrete delivery point to the locations of final deposit. Keep interior surfaces of conveying equipment, including chutes, free of hardened concrete, debris, water, snow, ice and other deleterious materials.

3. Do not use chutes for distributing concrete unless approved in writing by the Engineer.

4. Pumping of concrete is permitted, however, do not use aluminum piping to convey the concrete.

D. Placing Concrete into Forms

1. Deposit concrete in forms in horizontal layers not deeper than 18 inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place concrete at such a rate that concrete, which is being integrated with fresh concrete is still plastic with adequate vibration.

2. Do not permit concrete to free fall within the form from a distance exceeding 4 feet. Use "elephant trunks" and tremies to prevent free fall and excessive splashing on forms and reinforcement.

3. Remove temporary spreaders in forms when concrete placing has reached the elevation of such spreaders.

4. Consolidate concrete placed in forms by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping. Use equipment and procedures for consolidation of concrete in accordance with the applicable recommended practices of ACI 309. Vibration of forms and reinforcing will not be permitted, unless otherwise accepted by the Engineer.

5. Do not use vibrators to transport concrete inside of forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than the visible effectiveness of the machine. Place vibrators to rapidly penetrate the layer of concrete and at least 6 inches into the preceding layer. At each insertion, limit the duration of vibration to the time necessary to consolidate the concrete and complete embedment of reinforcement and other embedded items without causing segregation of the mix.

6. Force concrete under pipes, sleeves, openings and inserts from one side until visible from the other side to prevent voids.

E. Placing Concrete Slabs and Sidewalks

1. Deposit and consolidate concrete slabs in a continuous operation, within the limits of expansion joints, until the placing of a panel or section is completed.

2. Consolidate concrete during placing operations using mechanical vibrating equipment, so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.

3. Bring slab surfaces to the correct level. Smooth the surface, leaving it free of humps or hollows. Do not sprinkle water on the plastic surface. Do not disturb the slab surfaces prior to beginning finishing operations. Coordinate applying contraction joint with finishing operations.

F. Cold Weather Placing

1. Protect all concrete Work from physical damage or reduced strength, which could be caused by frost, freezing actions, or low temperatures, in compliance with the requirements of ACI 306 and as herein specified.
2. When the air temperature has fallen to or may be expected to fall below 40 F, provide adequate means to maintain the temperature, in the area where concrete is being placed, at between 50°F and 70°F for at least seven days after placing. Provide temporary housings or coverings including tarpaulins or plastic film. Maintain the heat and protection, if necessary, to ensure that the ambient temperature does not fall below 30°F in the 24 hours following the seven-day period. Avoid rapid dry-out of concrete due to overheating, and avoid thermal shock due to sudden cooling or heating.
3. When air temperature has fallen to or is expected to fall below 40 F uniformly heat all water and aggregates before mixing as required to obtain a concrete mixture temperature of not less than 55°F and not more than 90°F at point of placement.
4. Do not use frozen materials containing ice or snow. Ascertain that forms, reinforcing- steel, and adjacent concrete surfaces are entirely free of frost, snow and ice before placing concrete.
5. Do not use salt and other materials containing anti freeze agents or chemical accelerators, or set-control admixtures, unless approved by the Engineer, in mix designs.

G. Hot Weather Placing

1. When hot weather conditions exist that would seriously impair the quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.
2. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90°F when the temperature is rising and below 85°F when the temperature is falling. Mixing water may be chilled, or chopped ice may be used to control the concrete temperature provided the water equivalent of the ice is calculated by the Engineer in the total amount of mixing water.
3. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that the steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.
4. Wet forms thoroughly before placing concrete.
5. Do not place concrete at a temperature so as to cause difficulty from loss of slump, flash set, or cold joints.
6. Do not use set-control admixtures unless approved by the Engineer in mix designs.
7. Obtain Engineer's approval of other methods and materials proposed for use.

3.04 CONSTRUCTION JOINTS

A. Formed Construction Joints in Containment Structures and Where Otherwise Shown: Prior to placing concrete next to the joint, the joint surface shall be thoroughly cleaned and dampened with water. Remove all free water so that the surface of the joint shows signs of drying before placing the adjacent concrete.

B. Construction Joints in Beams, Girders and Slabs: These joints shall be located at points of minimum shear and their locations shall be approved by the Engineer before they are bulkheaded. These joints shall be roughened and thoroughly cleaned of all foreign matter and laitance and dampened with water. Remove all free water and slush with a coat of neat cements grout before placing the adjacent concrete. Place the adjacent concrete before the neat cements grout takes its initial set.

3.05 WATERSTOPS

A. Waterstops shall be provide where specified and as indicated and noted on the Drawings and shall be made continuous throughout their length.

3.06 FINISH ON FORMED SURFACES

A. Smooth Form Finish is required for all concrete surfaces exposed to view in the completed work and inside surfaces of all liquid containment structure walls whether exposed to view or not in the completed work. Accomplish the required patching and the following touch-up:

1. Remove all burrs.
2. Remove all form marks.
3. Smooth out lines of indentations.
4. Remove form ties and fill in indentations.

B. Rough Form Finish shall be produced by filling all tie holes and honeycomb and in other respects leaving the surface as formed. All concrete surfaces which will be covered by earth and whichwill not be visible in the completed structure (except as noted above for liquid containment structure walls which shall have a Smooth Form Finish), may receive a Rough Form Finish.

3.07 STEEL TROWELED FINISH – FLOOR SLABS

A. Steel troweled finish shall be applied to the surface of all building and liquid containment structure floor slabs and interior equipment pads.

B. Concrete shall be placed, consolidated, struck-off and leveled to the proper elevation. After the surface has stiffened sufficiently to permit the operation and the water sheen has disappeared, the surface shall be wood floated, by hand or power floated, at least twice, to a uniform sandy texture. Floors shall be leveled such that depressions between high spots do not exceed ¼-inch under a 10 foot straightedge except where drains occur, in which case the floors shall be pitched to the drains as indicated on the Drawings.

C. After the concrete has received a wood float finish, it shall be troweled at least twice to a smooth dense finish. The drying of the surface moisture between floating or troweled shall not be hastened by the dusting on of dry sand or cement. The first troweling shall be done by a power trowel and shall produce a smooth surface relatively free of defects. Additional troweling shall be done by hand after the surface has hardened sufficiently. The final troweling shall be done when a ringing sound is produced as the trowel is moved over the surface. The surface shall be thoroughly consolidated by the hand troweling operations. The finished surface shall be free of any trowel marks or other imperfections; shall be uniform in texture and appearance, and shall be

in true plane within the tolerance specified. Any deviation from this condition, which remains

after the troweling is complete, shall be corrected by grinding.

3.08 WOOD FLOAT FINISH

A. A wood float finish shall be applied to all base and top slabs in the diversion structures.

3.09 BROOM FINISH

A. Broom finish shall be applied to:

1. All exterior sidewalks, walkways and platforms.
2. All steps and landings, both interior or exterior.

B. The surface shall be given a floated finish as specified above, then finished with a flexible bristle broom or burlap belt drawn across the surface. Surface must be hardened sufficiently to retain the scoring or ridges. Scores or ridges shall be transverse to traffic or at right angles to the slope of the slab.

3.10 PROTECTION

A. Protect freshly placed concrete from damage or injury due to water, falling objects, persons or anything that may mar or injure finish surface on concrete. Only light use of slabs will be permitted for the first 14 days after placing of the concrete.

3.11 CURING

A. Curing shall conform to ACI 308 except as modified herein.

B. All Slabs on Grade: After placement and finishing, concrete shall be maintained in a moist condition for at least seven successive days during which the temperature of the concrete is 50 degrees F or above. For temperatures of 50 degrees F and below, curing period shall be 14 successive days. Concrete shall be kept moist by any one, or combination, of the following methods:

1. Ponding or Immersion: Continually immerse the concrete in water throughout the curing period. Water shall not be more than 20 degrees F less than the temperature of the concrete.
2. Fog Spraying or Sprinkling: Provide uniform and continuous application of water throughout the curing period.
3. Pervious Sheeting: Completely cover surface and edges of the concrete with two thicknesses of wet sheeting. Overlap sheeting 6-inches over adjacent sheeting. Sheeting shall be at least as long as the width of the surface to be cured. During application, do not drag the sheeting over the finished concrete nor over sheeting already placed. Wet sheeting thoroughly and keep continuously wet throughout the curing period.
4. Impervious Sheeting: Wet the entire exposed surface of the concrete thoroughly with a fine spray of water and cover with impervious sheeting throughout the curing period. Lay sheeting directly on the concrete surface and overlap edges 12-inches minimum. Provide sheeting lot less than 18-inches wider than the concrete surface to be cured. Secure edges and transverse laps to form closed joints. Repair torn or damaged sheeting or provide new sheeting. Inspect surface of concrete daily for wetness. The surface shall be kept

continuously wet during the curing period.

C. All Other Concrete

1. After placement, concrete shall be maintained in a moist condition for the same periods as specified above for slabs on grade. For concrete in formed surfaces, keep forms wet with water during the curing period. If forms are removed before the end of the curing period, continue the moist curing in accordance with Paragraph B of this Article of these Specifications.

3.12 PATCHING

A. As determined by the Engineer, any concrete, which is out of alignment or level has a defective surface or has defects, which reduce its structural adequacy, shall be considered as not conforming with the Drawings and Specifications and shall be rejected.

B. Do not take any remedial action on concrete with any defect without the permission of the Engineer.

C. Unless the Engineer grants permission to patch the rejected concrete, remove the rejected concrete and replace it with concrete that conforms to the Drawings and Specifications. The location of cut lines and the extent of removal will be determined by the Engineer.

D. If the Engineer grants permission to patch the rejected concrete, it shall be done in accordance with the following:

1. Permission to patch rejected concrete will not be a waiver of the Engineer's right to require complete removal of the rejected concrete if the patching does not, in the Engineer's judgment, restore the concrete to the requirements of the Specifications and Drawings.
2. Patching shall be accomplished after the curing is completed.
3. Defective areas shall be chipped away to a depth of not less than 1-inch, in all cases to sound concrete, with edges perpendicular to the surface. Feather edges will not be permitted. Remove all loose material and thoroughly clean the chipped surfaces with a high pressure air hose delivering air at 100 psi. The area to be patched and an area at least 6-inches wide surrounding it shall be dampened. A bonding grout shall be prepared using a mix of approximately one part cement to one part fine sand passing a No. 30 mesh sieve, mixed to the consistency of thick cream, and then well brushed into the surfaces as noted in paragraph 5.
4. The patching mixture shall be made of the same materials and of approximately the same portions as used for the original concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of not more than one part cement to two and one-half parts sand by damp, loose volume. While Portland cement shall be substituted for a part of the gray Portland cement to produce a color matching the color of the surrounding concrete, as determined by a trial patch. The quantity of mixing water shall be no more than necessary for handling and placing. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel, without addition of water, until it has reached the stiffest consistency that will permit placing.

5. After surface water has evaporated from the area to be patched, the bond coat shall be well brushed into the surface. When the bond coat begins to lose the water sheen, the premixed patching mortar shall be applied. The mortar shall be thoroughly consolidated into place and struck off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, it shall be left undisturbed for at least one hour before being finally finished. The patched area shall be kept damp for seven days. Finishing tools that produce a finish matching the surrounding shall be used.

E. Tie holes left by withdrawal of rods or the holes lefty by removal of ends of wall ties shall be filled solid with mortar after first being wetted. For holes passing through the wall, a plunger-type grout gun shall be used to force the mortar through the wall starting at the back face. A piece of burlap or canvas shall be held over the hole on the outside and when the hole is filled, the excess mortar shall be struck off with the cloth flush with the surface. Holes not passing through the walls shall be filled with a small tool that will permit packing the hole solid with mortar. Any excess mortar at the surface of the wall shall be struck off flush with a cloth. Mortar shall consist of one part cement, two and one-half parts sand and no more water than necessary for handling and packing.

3.13 QUALITY CONTROL TESTING

A. The Independent testing laboratory shall have access to all places where concrete materials and concretes are manufactured, stored, proportioned, mixed, placed and tested. Duties shall include, but not necessarily be limited to the following:

1. Make, store, transport, cure and test compression specimens made during the placing of concrete. Compression test specimens shall be tested in accordance with ASTM C 39. Test reports shall show all pertinent data, such as class of concrete, exact location of pour, air temperature, date of pour, time of pour, truck number for ready-mixed concrete, date on which specimen was broken, age of specimen, compressive strength of specimen, concrete slump test results and air content of concrete from which the specimen was made. One copy each of all tests shall be sent to the Contractor and two copies each to the Engineer.
2. Each strength test requires four standard test cylinders.
3. Samples for strength tests of each class of concrete placed each day shall be taken not less than once a day, nor less than once for each 50 cubic yards of concrete, nor less than once for each 5,000 square feet of surface area for slabs or walls.
4. Each class of concrete shall be tested with at least five strength tests.
5. Each set of four cylinders, two shall be tested at 28 days and shall comprise a strength test under the definition of these Specifications. One cylinder shall be broken at seven days and will be used as an aid in determining the early strength of the concrete and the 28 day strength, and one cylinder retained in reserve for later testing if required.
6. Test for unit weight of concrete when the first load of each class of concrete is delivered and thereafter at the discretion of the testing laboratory.

B. Periodically inspect the batching plant and file a report with the Engineer stating whether the supplier's equipment and methods meet the requirements of these Specifications.

C. Temperature and Placing Record: Temperature record shall be made each day during the concreting operations. Records shall also include location, quantity and starting and finishing time of placement for all concrete work. Copy distribution shall be as specified above for test reports.

D. All work and reports shall comply with Applicable Industry Standards.

3.14 EVALUATION OF COMPRESSION TESTS

A. Evaluation of compression test results shall be as follows: For each class of concrete, compression-strength tests for laboratory-cured cylinders shall be considered satisfactory if the averages of the results of all sets of three consecutive compression-strength tests equal or exceed the 28 day design compression-strength specified; and, no individual cylinder strength test falls below the required compression strength by more than 500 psi. Strength tests of specimens cured under field conditions may be required by the Engineer to check the adequacy of curing and protecting of the concrete placed. Specimens shall be molded by the field testing laboratory at the same time and from the same samples as the laboratory-cured specimens.

B. Faulty Concrete: Failure to comply with any of the specified conditions shall constitute faulty concrete. Unless otherwise directed by the Engineer, faulty concrete shall be removed and replaced with concrete as specified, at no expense to the Owner.

C. Additional Test: If permitted by the Engineer, additional tests shall be subject to the approval of the Engineer at no expense to the Owner. Load tests, if permitted by the Engineer, shall be conducted in accordance with the loading criteria as required by the design of the structure, as determined by the Engineer.

D. Neither the results of laboratory verification tests nor any provision in the Contract Documents shall relieve the Contractor of the obligation to furnish concrete of the class and strength specified.

3.15 TESTING FOR WATERTIGHTNESS OF CONCRETE STRUCTURES

A. Leakage testing shall be carried out in accordance with ACI 350.1 - Tightness Testing of Environmental Engineering Concrete Structures. The test criterion shall be HST-NML (no measurable loss) as defined by ACI".

B. All concrete structures designed to contain or convey fluid shall be tested for watertightness by the Contractor prior to earth backfilling by filling with water to levels approximately what will be attained during operation and measuring the drop in level due to leakage, if any. These tests shall be made under the direction of the Engineer, and if necessary the tests shall be repeated until watertightness is ensured. Perform tests prior to backfilling below grade structures and prior to installations of any coating.

C. Rate of filling shall be limited to minimize shock-effect to new concrete construction. Water shall be held under each condition long enough to satisfy the Engineer that the structures are watertight. Structures shall be free of internal or external water leakage.

D. Leakage shall be located and stopped and the structure again tested until this requirement is met. If the structure does not meet the test, the Contractor shall repair or replace at his own expense, such part of the work as may be necessary to secure the desired results, as approved by the Engineer.

E. Regardless of the rate of leakage there shall be no visible leakage from any concrete structure.

END OF SECTION 03300

SECTION 03345
CONCRETE FLOOR TREATMENT

PART 1 - GENERAL

1.01 SCOPE

A. Provide surface treatment for dustproofing, hardening, and sealing exposed concrete floors in electrical and valve rooms.

1.02 RELATED WORK

A. Section 03300: Cast-in-Place Concrete

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM) Publications:

1. D4263: Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.

1.04 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions. In addition, the following specific information shall be provided:

1. Submit manufacturer's product data.
2. Submit manufacturer's surface preparation and application instructions.
3. Submit manufacturer's color charts.

1.05 DELIVERY, STORAGE AND HANDLING

A. Provide in accordance with Sections 01610 and 01611.

PART 2 - PRODUCTS

2.01 DUSTPROOF/SEALER (DPS)

A. Manufacturers:

1. Armorseal Rexthane 1 manufactured by Sherwin Williams.
2. Duraguard 300HS manufactured by ChemMasters.
3. Eucothane manufactured by the Euclid Chemical Company.
4. Or equal.

B. Provide a high solids, single component, moisture cure urethane with VOC compliance.

C. Provide surface primer in accordance with manufacturer's printed instructions.

D. Colors as indicated in Finish Schedule.

PART 3 - EXECUTION

3.01 SURFACE PREPARATION

A. General:

1. Prepare concrete surfaces in accordance with manufacturer's printed instructions. Concrete shall be cured for a minimum of 28 days prior to application of floor treatment.
2. Acid etching will not be allowed.
3. Concrete surfaces shall be free of dirt, oil, wax, sealers, grease, rust stains, curing and parting compounds and other foreign matter.

3.02 APPLICATION

A. Dustproof/Sealer (DPS):

1. Perform testing for vapor drive on concrete floors in accordance with ASTM D4263 prior to application. Do not apply dustproof/sealer until test results have been approved by Engineer.
2. Apply primer in accordance with manufacturer's printed instructions.
3. Give particular attention to priming of concrete substrate and time laps between coats when more than one conditioning coat is required.
4. Mix colored polyurethane dustproof/sealer surface treatment and apply to sound, fully cured, dry and thoroughly clean concrete slabs in strict accordance with manufacturer's printed instructions.
   a. Total dry film thickness for both primer and topcoat shall be 4 mils.

END OF SECTION 03345

SECTION 03361
SHOTCRETE

PART 1 - GENERAL

1.01 SCOPE

A. The work specified in this Section includes furnishing all materials, equipment, testing, production and application of shotcrete to the specified thickness at the locations shown on the Drawings.

1.02 DEFINITIONS

A. Plain shotcrete: Portland cement concrete mixture applied from a spray nozzle at high velocity by means of compressed air and containing, if necessary, admixtures to provide quick set, high early strength, and satisfactory adhesion to the rock.

B. Rebound: All material having passed through the nozzle which does not adhere to the surface on which shotcrete is being applied.

C. Dry Mix Process: Shotcrete in which a premixed blend of cement and aggregate is propelled through a hose by compressed air to the nozzle. Water is added to the cement and aggregate mixture at the nozzle and the intimately mixed ingredients are projected onto the surface. Accelerator may be added to the shotcrete mixture at the nozzle in such a way that the quantity can be properly regulated.

D. Steel Fiber: Discrete, cold-drawn, steel wire fibers which can be uniformly distributed in shotcrete to improve the toughness.

E. Synthetic Fiber: Macro-synthetic polypropylene fibers with an equivalent diameter between 0.025 inches and 0.035 inches which can be uniformly distributed in shotcrete to improve the toughness.

F. Fiber reinforced shotcrete: Similar to "plain shotcrete" except that, in addition to the plain shotcrete mix, steel fibers or macro-synthetic polypropylene fibers are incorporated into the mix.

G. Wet mix process: Shotcrete in which all the ingredients except the accelerator are mixed before introduction in the delivery hose. Accelerator is added to the shotcrete mixture at the nozzle in such a way that the quantity can be properly regulated.

1.03 QUALIFICATIONS

A. Foremen and nozzlemen, before employment on the work, shall satisfy the Engineer that each has done satisfactory work in similar capacities elsewhere for a sufficient period of time to be fully qualified to properly perform the work in accordance with the requirements indicated. Foremen shall have at least two years experience as a nozzleman, and at least two years experience as a foreman on similar work. Nozzleman shall be certified by the American Concrete Institute as outlined in ACI Certification CP 60(09) for both vertical and overhead applications for the method of shotcreting (wet mix or dry mix) that will be used on the project.

B. Each shotcreting crew will be required to fabricate two acceptable test panels for each mix and in each shooting position which the crew will encounter in the Work, prior to application of shotcrete in the Work, using the exact type of equipment intended to be used by the crew. Crews lacking acceptable proficiency, as determined by the Engineer, shall not be permitted to work on the project. The procedure for completing the test panels are in Article 1.04 C herein. Refer to Article 3.01 for requirements.

C. Should the results of control testing indicate that deficient shotcrete is being produced by a crew, the crew may be required to be requalified for the mix and shooting position in question at no additional cost to the Owner.

1.04 QUALITY ASSURANCE

A. The Contractor shall be responsible for the design of all shotcrete mixes and for the quality of the shotcrete placed in the work.

B. Pre-construction test panels and construction test panels or test cores from the in-place shotcrete are required. Shotcreting and coring of test panels shall be performed by qualified personnel in the presence of the Engineer. The Contractor shall provide the equipment, materials, and personnel as necessary to obtain shotcrete cores for testing including construction of test panel boxes, field curing requirements and coring.

C. Pre-construction Trial – A pre-construction trial shall be used to pre-qualify the nozzlemen and mix designs for the Project. Test panels shall be constructed by each crew using the equipment, materials, mix proportions, and procedures proposed for the applications. All test panels shall be constructed at an approved location on the Project site. Those mixes to be applied using a shotcrete boom shall have test panels made using the remote boom. Each crew shall construct two test panels for each mix type and for each shooting position (i.e. vertical and overhead).

1. The test panels shall be produced in accordance with the requirements of ASTM C1140 except that they shall have minimum dimension of 30 inches x 30 inches x 6 inches deep and shall have 45 degree sloped edges to permit escape of rebound. The panels may be constructed of wood or steel as specified in ASTM C1140.
2. The test panel must be securely fastened to a rigid structure to prevent vibration during placement.
3. Test panels shall be shot in vertical and horizontal (overhead) positions.
4. Test panels shall be field cured in the same manner proposed for the production shotcrete work until they are delivered to the laboratory or test specimens are extracted. During field curing, the panels shall be kept out of the sun and kept from freezing.
5. The Contractor shall core nine, 3-inch diameter samples from each test panel in the presence of the Engineer following the procedures in ASTM C 42 and ASTM C 1140. The minimum length of the core shall be equal to the diameter.
6. Core samples, for each set of test panels, will be taken at different times, corresponding to the specified strength ages in Section 2.03. Core samples shall be identified by mix designation, test panel number, and whether the test panel was vertical or horizontal. The cores shall be moist cured but not immersed, from the time they are taken to the time they are tested. The Contractor shall be responsible for pre-construction testing.

7. At least three specimens from each panel shall be tested for 24-hour, 72-hour and 28-day strength. The testing facility shall test the core for compressive strength in accordance with ASTM C1604/ C1604M.

8. At least three, 4-inch by 4-inch by 14-inch beams shall be extracted from each test panel of reinforced shotcrete in accordance with ASTM C1140 and shall be tested for flexural strength in accordance with ASTM C 1609/C 1609M. Beams shall be taken within two days of shooting test panels and wet cured until the time of the test.

9. The compressive strength of all cores from each test panel and flexural strength for the beam samples shall test to at least 100 percent of the strengths specified for each age in Section 2.03.

10. If the pre-construction test specimens fail to meet the performance requirements, the Contractor shall make the necessary adjustments in materials, mixture proportions, or application procedures and re-shoot the test panels. No shotcrete work shall commence until the pre-construction testing requirements have been met.

11. The exact proportions of ingredients determined on the basis of pre-construction tests shall be used in the actual application of shotcrete and shall not be varied without the written approval of the Engineer.

D. Construction Testing - Construction testing may be performed using test panels or coring of the in-place shotcrete or a combination of either method as determined by the Engineer.

1. Test cores shall be obtained from partially applied shotcrete or completed shotcrete at the Engineer's discretion. The Engineer will determine the locations and dates for test coring.

2. One construction test panel shall be made for every 50 cubic yards of shotcrete being placed. The test panels shall be constructed the same as the pre-construction test panels. The frequency of core sampling will average three cores for every 50 cubic yards of shotcrete placed. Additional cores may be sampled at the discretion of the Engineer.

3. Core sample collection shall be done following ASTM C 1140. The Contractor shall perform the core sampling and collect 3-inch diameter core samples. If any sample fails to meet the size requirements for the test, the Engineer shall select an alternative location from which to get a sample.

4. The average 28 day compressive strength of three cores taken from the test panels must equal or exceed the strength specified in Article 2.03 with no individual cores less than 0.85 times the strength specified in Article 2.03.

5. If one of a set of three samples taken in any section of the work or the average fails to meet the minimum compressive strength requirements, the Contractor shall core three additional samples from within five feet of the location of the failed sample. If one of these samples or the average of the three samples fails to meet the minimum strength criteria noted above, then remedial work shall be performed, including application of additional thickness of shotcrete or removal and replacement of the defective shotcrete as directed by the Engineer. Such additional sampling, testing, and remedial work shall be performed at no additional cost to the Owner.

6. Additional specimens may be required at any time by the Engineer. Should additional specimens show acceptable strength, the Contractor will be reimbursed for the cost of obtaining such additional samples. Should these specimens fail, the cost of additional specimens shall be deemed incidental to the work.

7. Flexural strength testing of production shotcrete will not be regularly required by the Engineer. However, the Contractor shall confirm the fiber content of the production shotcrete mix by determining the fibers in a known volume of production shotcrete using a method acceptable to the Engineer.

8. The voids caused by the coring shall be plugged by the Contractor.

9. If any cores taken fail to show adequate bond with the rock, or bond between layers, or show obvious defects, two additional cores shall be taken within approximately five feet of the unsatisfactory core. If either of these fails to show adequate bond with the rock or show obvious defects, the Engineer may require shotcrete in the area surrounding the unsatisfactory cores to be removed and replaced at no cost to the Owner.

10. If the shotcreting system selected by the Contractor fails to provide satisfactory in-place shotcrete in accordance with these Specifications, the Contractor shall immediately modify his procedures, mix design, equipment, or system to produce the specified quality.

1.05 SUBMITTALS

A. Submit the following information in accordance with the General Conditions and at least 60 days before the start of shotcrete placement;

1. Documentation of the qualifications and experience of shotcreting crew including the foreman and nozzleman.

2. Manufacturer's certifications showing source and proof of conformance to project specifications for all shotcrete materials including cement, silica fume, fly ash, aggregate (source, gradation, bulk density and absorption), water source, chemical admixtures, and fiber reinforcement.

3. Proposed source of shotcrete and shotcrete mixture proportions, including batch quantities of aggregate, cementitous materials, fibers, expected water demand, chemical admixtures, accelerator and proposed mix, proposed placing equipment, and methods of application.

4. Proposed methods for mixing, conveying, finishing, curing and testing along with a list of proposed equipment for each task.

5. Laboratory test reports of proposed mix and compatibility test results prior to first time use and any change in cement/additive/water source.

6. Details of proposed Safety Plan including description of personal protective equipment, description of procedures for handling potentially hazardous materials such as admixtures and accelerators, ventilation plan, communication plan, and plan for controlling dust and vapor.

B. After completion of laboratory testing and preconstruction testing and at least 28 days before application of shotcrete to the work, the following shall be submitted:

1. Laboratory report of strength tests on beams and cores from test panels that include;
   a. specimen identification, including mix designation and test panel number.
   b. date and time of application of shotcrete.
   c. date and time specimen was tested.
   d. curing time for each specimen.

e. dimensions of each specimen and sketch of specimen at failure.

f. load-deflection diagrams from flexural beam testing.

C. During construction:

1. Submit test samples from test panels or in-place coring.
2. Sample test results.
3. Shotcrete batch/delivery tickets as applicable.

D. Daily progress reports to the Engineer documenting shotcrete operations. The reports shall contain the following information, as a minimum:

1. The areas where shotcrete was placed each day by each nozzleman. Areas shall be indicated by station, elevation, and/or sketch, indicating volume placed. Identify nozzleman and foreman on each report.
2. The date and time each area was placed.
3. Maximum and minimum air temperature.
4. The curing and protective measures employed.
5. Estimate of the percentage of rebound.
6. Description of any special conditions or problems encountered.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

A. All materials shall be stored in conformance with the manufacturer's recommendations.

B. Aggregate shall be stored so that deleterious substances and foreign matter are excluded, coarse and fine aggregate are kept separate, proper temperatures are maintained, and water contents are controlled by means of drainage and/or sheltering the piles from the weather.

C. Workers shall wear proper protective clothing and attend safety meetings pertaining to shotcrete operations.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Cement shall conform to ASTM C 150, Type I or Type III.

B. All mixing water for shotcrete shall be potable and meet the requirements of ASTM C 1602/C 1602M. Water quality shall be verified prior to use.

C. Silica fume shall comply with ASTM C 1240.

Admixtures shall comply with ASTM C 1141 and be certified as chloride free. Approval for the use of accelerators will be based on test results from test panels and cement-additive compatibility tests performed by the Contractor. Results of compatibility tests shall be submittedto the Engineer prior to shooting test panels. Admixtures shall be limited to the types specified and shall be added in the prescribed manner and dosage.

D. Fibers

1. Steel Fibers
   a. Shall conform to ASTM A820 and be suitable for production of ASTM C1116/ C116M Type I steel fiber reinforced shotcrete.
   b. Steel fiber shall be bent or deformed-end low carbon, cold drawn steel wire, Type I with a minimum tensile strength of 160,000 psi and a minimum length of 1 inch and a minimum aspect ratio of 40.
   c. Steel fibers shall be free of oil, grease, or other contaminants.
2. Synthetic Fibers
   a. Shall be suitable for production of ASTM C1116 Type III synthetic fiber reinforced shotcrete.
   b. Shall have a minimum length of 1 inch and a minimum aspect ratio of 40.
   c. Synthetic fibers shall be free of oil, grease, or other contaminants.

E. Aggregate shall be normal weight aggregate conforming to the requirements of ASTM C 33, except that the gradation of combined coarse and fine aggregate shall conform to Gradation No. 2:

U.S. Standard Sieve Size Square Mesh	Percent Finer By Weight
	Gradation 2
1/2-inch	100
3/8-inch	90 - 100
No. 4	70 – 85
No. 8	50 – 70
No. 16	35 – 55
No. 30	20 – 35
No. 50	8 – 20
No. 100	2 – 10
No. 200	0 – 5

F. Aggregate source or gradation shall not be changed during the course of the work without prior testing and approval by the Engineer.

2.02 EQUIPMENT

A. All equipment shall be operated, tested, and maintained in accordance with the manufacturer's instructions for the entire duration of the shotcreteing work.

B. Batching facility and proportioning devices shall provide exact amounts of ingredients in proportions required.

C. The shotcrete equipment shall be capable of feeding materials at a regular rate and ejecting shotcrete from the nozzle at velocities that will allow adherence of the materials to surface being shotcreted with a minimum of rebound and maximum adhesion and density.

D. For dry mixing process, placing equipment shall consist of a spray nozzle providing for ejection of materials and water in an intimate mixture.

E. For wet mixing process, accelerating admixtures shall be introduced into the shotcrete mix in the quantities permitted by means of a properly calibrated dispensing machine or dosage pump. Pumping shall ensure a continuous conveyance of base materials.

F. Equipment shall be provided to allow application of shotcrete to all surfaces at the appropriate distance from the nozzle and as perpendicular to the receiving surface as possible.

G. Dust shall be controlled by means of dust collectors and/or increased ventilation capacity in the vicinity of the workers.

2.03 MIX DESIGN REQUIREMENTS

A. The Contractor shall be responsible for developing the mix design for all shotcrete used on the Project that meets the strength requirements. The Engineer will inform the Contractor in writing of his approval of mixes that meet the requirements. No shotcrete mix shall be used that has not been accepted by the Engineer. Either wet or dry mix process shall be used. Shotcrete shall conform to the following criteria:

B. Compressive Strength

1. The mix design for shotcrete compressive strengths shall be such as to develop compressive strength progressively as follows:
   a. 1,100 psi minimum at 24 hours
   b. 2,100 psi minimum at 72 hours
   c. 5,000 psi minimum at 28 days
2. Compressive strengths stated above shall be for three-inch diameter test specimens tested following ASTM C1604 / C1604M.

C. Flexural Strength

1. Reinforced shotcrete shall have the following flexural strength properties determined in accordance and ASTM C1609/ C1609M. The tests shall be conducted on 4 inch by 4 inch by 14 inch long beam samples.
   a. minimum peak flexural strength, fp, at seven days, greater than or equal to 580 psi.
   b. minimum residual flexural strengths greater than or equal to:
      i) f100,0.5 - 290 psi
      ii) f100,2.0 - 170 psi

PART 3 - EXECUTION

3.01 QUALIFICATIONS FOR NOZZLEMEN AND MIXES

A. The mix design and nozzlemen proposed shall be considered satisfactory for use on the work if the following criteria are met:

1. All cored or broken surfaces are dense and free from laminations or sand pockets.
2. All reinforcing is completely encapsulated with shotcrete, and the shotcrete surrounding the reinforcing is dense and free from voids or honeycomb (applies only to panels or test sections containing reinforcing).

3. The average compressive strength of the cores and flexural strengths for the beam samples from each panel is at least equal to the strength criteria specified in Article 2.03 of this Section.

4. Test sections do not show excessive sloughage or rebound of material during placement.

5. In-place coring and sounding of test sections show proper bonding of shotcrete to rock.

3.02 BATCHING, MIXING AND SUPPLY

A. Wet mix shotcrete shall be batched, mixed and supplied using one of these methods; central mixing with transit mixture delivery; transit mixing and delivery; packaged, pre-blended, dry combined materials with water added on site. Volumetric batching will not be allowed.

1. Central mixing and supply
   a. Aggregate, cement and supplementary cementitious materials and fibers shall be mass batched in a central mix plant and delivered in a transit mixer in accordance with the requirements of ASTM C94 or C1116. Water and chemical admixtures shall be either mass or volumetrically batched. Weighing equipment shall be capable of batching to the accuracy specified in ASTM C1116 / C1116M.
   b. Add shotcrete materials, including fibers, in a sequence that ensures uniform mixing and dispersion.
   c. Transit mixers shall be free of accumulations of hardened concrete or shotcrete in the drum or blades. Transit delivery shall conform to the requirements of ASTM C94 / C94M.
   d. All shotcrete shall be shot within 90 minutes after addition of mixing water to the batch unless otherwise approved.

2. Transit mixing and supply
   a. The same requirements shall apply as specified for central mixing except that all ingredients shall be added directly to the transit mixer. Transit mixers shall be charged to no more than 70 percent of their rated capacity, to enable efficient mixing action.

3. Packaged, pre-blended, dry, combined supply
   a. The use of packaged supply with water addition at the site shall be permitted provided that the Contractor can demonstrate uniform mixing of the shotcrete and satisfactory conformance to all the Project performance requirements.
   b. Packaged shotcrete shall be mass-batched in conformance with the requirements of ASTM C1480 / C1480 M. All aggregates shall be dried to a moisture content of less than 0.1 percent by mass based on oven drying at 105° to 110° C.

B. Dry mix shotcrete shall be batched, mixed and supplied using one of these methods: site batching using mass batching units and rotary transit mixer supply, or packaged, pre-blended, dry, combined material supplied in bags.

1. Mass batching and supply: The same criteria shall apply as for central mixing and supply of wet mix shotcrete (Article 3.02 A.1), except that the bulk of the water shall be added at the water ring during the shotcrete application process, and all dry mix shotcrete shall be shot within 45 minutes of first contact of cement with moisture.

2. Packaged, pre-blended, dry, combined batching and supply
   a. Packaged shotcrete shall be mass-batched in conformance with the requirements of ASTM C1480. All aggregates shall be dried to a moisture content of less than 0.1 percent by mass based on oven drying at 105 to 110o C.
   b. Protect packaged shotcrete from exposure to moisture during handling, transport, and storage. Discard any bags that display lumps of pre-hydrated shotcrete.

3.03 SURFACE PREPARATION

A. All rock surfaces shall be scaled to remove loose rock prior to shotcrete operation.

B. Rock surfaces upon which shotcrete is to be placed shall be cleaned with air and/or water and shall be free from oil, standing or running water, mud, rebound, overspray, or other objectionable coatings that will prevent bonding of shotcrete to the rock. Rock surfaces receiving shotcrete shall be in a saturated-surface-dry condition just prior to placing shotcrete.

C. Certain rock conditions may require special preparations. Joints or seams having loose rock fragments or soft or swelling fillings shall be excavated and grouted or packed as directed by the Engineer. Joints or seams having clay or slick surfaces shall be cleaned and roughened to promote bonding of shotcrete.

D. Groundwater shall be controlled by means of grouting, installing drain pipes, panning, backdrains, underdrains, sandbagging, channeling, or other means accepted by the Engineer. Immediately before shotcrete placement, all rock surfaces shall be cleaned and water diverted to the satisfaction of the Engineer.

E. Non-corrosive measuring pins shall be installed on five foot centers to allow verification of shotcrete thickness. Other methods which permit direct measurement of the applied shotcrete thickness may be acceptable if the Contractor can demonstrate their reliability and compatibility with the Contractor's shotcreting activities.

3.04 APPLICATION OF SHOTCRETE

A. The amount of water used in each mix shall in no case be greater than that used for the same mix shot on a vertical surface. The Engineer may at any time require a demonstration that an excess of water is not being used, by shooting a test piece on a vertical surface.

B. Shotcrete shall not be placed when the ambient temperature is less than 40° F, except when measures approved by the Engineer are taken to maintain the temperature of the rock surface at or above 40° F for a minimum period of 48 hours prior to shotcreting.

C. Shotcrete shall be applied in accordance with good practice as outlined in ACI 506R. The nozzle shall be held at such distance and position that the stream of flowing material shall impinge as nearly as possible at right angles to the surfaces being covered and so that a minimum of rebound will fall on surfaces yet to be shot.

D. Precautions shall be taken to prevent overspray, rebound, or waste from being incorporated in the work area.

E. All rebound and waste shotcrete shall be removed and shall be disposed of in the designated disposal areas, as required by the Engineer. Rebound shall not be reclaimed for use in shotcrete.

F. All shotcrete shall be placed so that there will be no pockets of loose sand in any part of the work. Should any deposit of loose sand be covered with shotcrete, it shall be removed and replaced with acceptable shotcrete.

G. Shotcrete over the rock surface shall have a minimum thickness as shown on the Drawings.

H. Adequate ventilation and lighting shall be provided to the work area to ensure good visibility.

I. Construction joints shall be tapered over a minimum distance of 12 inches to a thin edge. The surface of the joint shall be thoroughly cleaned and wetted before additional shotcrete is placed on the joint.

J. Contractor shall coordinate with the Engineer to allow the geology to be mapped prior to shotcrete placement. The Contractor should assume that the mapping can be performed without delaying the shotcrete operation.

3.05 CURING AND PROTECTION

A. Initial Curing - Immediately after finishing, shotcrete shall be kept continuously moist for at least 3 days.

B. Final Curing - Additional curing shall be provided immediately following the initial curing and before the shotcrete has dried. One of the following materials or methods shall be used:

1. Continue the method used in initial curing.
2. Application of impervious sheet material conforming to ASTM C171.

C. Duration of Curing - Curing shall be continued for the first 7 days after shotcreting or until the specified compressive and flexural strength of the in-place shotcrete as determined by specimens obtained and tested in accordance with ASTM C42 is achieved.

D. Shotcrete shall be protected to maintain an internal temperature above 5° C until the specified 28-day strength is reached.

E. Before setting, shotcrete must be protected against running water, potential impact, and vibrations.

3.06 TESTS AND INSPECTIONS

A. The quality of in-place shotcrete will be monitored by the Engineer during placement. Improper placement techniques and areas of defective shotcrete shall be identified in the field for immediate correction and repair by the Contractor.

B. Final acceptance of in-place shotcrete shall be determined from tests on cores taken from the completed work or test panels as described in Article 1.04.

C. Shotcrete in-place shall be considered acceptable if it is: dense and free of laminations or sand pockets, there is no evidence of honeycomb or voids in the shotcrete, cores contain no evidence of poor bond between the substrate and the shotcrete, the thickness of shotcrete is as specified and as shown on the Drawings, the results of the strength testing from in-place shotcrete or test panels meet the requirements of Article 1.04 D.

D. If the results of the tests from the test panels or in-place work or assessment of the in-place shotcrete indicate non-conformance of the shotcrete to the specifications, the Engineer will implement a program of evaluation of the in-place shotcrete. The evaluation may include, but not be limited to, extraction of cores from the in-place work, and indirect methods to help assess the extent of defective areas.

E. Shotcrete that is non-conforming or defective shall be removed and replaced by the Contractor at no additional cost to the Owner.

3.07 FINISHED SHOTCRETE SURFACES

A. All unsound, honeycombed, poorly bonded, or otherwise defective shotcrete shall be removed as directed by the Engineer. Broken edges or abrupt changes in thickness shall be cut or chipped so that the roughened surface is tapered towards the center of the cavity. Additional shotcrete may be applied directly to a clean, moist, green shotcrete surface, but hardened shotcrete surfaces shall be prepared as outlined in ACI 506R and in a saturated-surface-dry condition just prior to placing shotcrete.

B. The surface finish on the specified profile shall be a gun finish, "as shot".

C. The core holes shall be patched by the Contractor with shotcrete materials premixed to the stiffest consistency that will permit tamping into place by use of hand or power rodding tools in accordance with ACI 301.

D. Remove and dispose of all rebound shotcrete and waste.

END OF SECTION 03361

SECTION 03414
PRESTRESSED CIRCULAR CONCRETE TANKS

PART 1 - GENERAL

1.01 SCOPE

A. The work covered by this section consists of furnishing all labor, equipment and materials required for the design, submittals, construction, and testing of the prestressed concrete wastewater equalization tank T-501 as shown on drawings and specified herein. The equalization tank layout shown on the drawings identifies the critical tank dimensions, wall, floor and roof penetrations and attached equipment and other information necessary to define the tank process requirements. It shall be the responsibility of the prestressed concrete tank contractor to provide the complete structural design for the tank wall and roof system with all openings and attachments and supports necessary for the process features shown on the drawings and identified herein. The structural floor with rock anchor layout has been designed in full by The Crom Corporation. The tank builder shall not deviate from the design presented herein.

B. The prestressed concrete tanks shall have prestressed walls in which a steel shell diaphragm of a height equal to the full wall height has been encased. All prestressing shall be done with high tensile steel permanently bonded to the tank wall.

C. The entire tank, including all portions of the floor, wall, and roof shall be built by the specialty tank contractor, using its own trained personnel and equipment.

1.02 REFERENCES

A. Standards of the following as referenced:

1. ACI 372R-03 – Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures.
2. AWWA D110-04 – Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks.
3. ACI 506R – Guide to Shotcrete.
4. ASTM A 821/A821M – Standard Specification for Steel Wire, Hard Drawn for Prestressing Concrete Tanks.
5. ASTM A 1008/A1008M – Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy With Improved Formability.
6. ASCE Standard 7-05 – Minimum Design Loads for Buildings and Other Structures.
7. ASTM C 881/C881M – Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
8. ASTM A 416/A416M – Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
9. ASTM A 884/A884M – Standard Specification for Epoxy Coated Steel Wire and Welded Wire Reinforcement.
10. ASTM A 185 – Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.

11. ASTM A 615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
12. ACI 305R – Hot Weather Concreting.
13. ACI 306R – Cold Weather Concreting.
14. ACI 350 – Building Code Requirements for Environmental Engineering Concrete Structures and Commentary.
15. ASTM C 31/C31M – Test Methods for Making and Curing Concrete Test Specimens in the Field.
16. ASTM C 39/C39M – Test Method for Compressive Strength of Cylindrical Concrete Specimens.
17. ASTM C 231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
18. ASTM C 143 – Standard Test Method for Slump of Hydraulic-Cement.
19. ASTM C 172 – Standard Practice for Sampling Freshly Mixed Concrete.
20. ASTM C 33/C33M – Specification for Concrete Aggregates.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with Section 01300 Submittals and shall include the following information:

1. Submit detailed design drawings showing all reinforcement, thickness of tank structure including floor, walls, dome and overcoat, location and details of all accessories required etc. sealed by a professional engineer registered in the state of Georgia.
2. Submit design calculations sealed by a professional engineer registered in the state of Georgia.
3. Submit mix designs for floor concrete mixes.
4. Submit mix designs for shotcrete mixes.
5. Submit mill test reports certifying the prestressing steel meets applicable ASTM standards.
6. Prestressing schedule including number and placement of prestressing wires on the tank wall and total applied force per foot of wall height.
7. Submit concrete strength reports for 7-day and 28-day breaks.
8. Project Record Documents: Record actual location layout and final configuration of tank and accessories on shop drawings and submit to engineer after construction of the tank is complete

1.04 QUALITY ASSURANCE AND QUALITY CONTROL

A. The prestressed concrete tank shall be designed and built in accordance with AWWA D110 Type II.

B. The Contractor shall retain a tank specialty contractor who shall be a specialist in the design and construction of circular prestressed concrete tanks. The tank specialty contractor shall have had

at least ten (10) years of experience in this specialty and have built, completely in its own name, in the past five (5) years, no less than ten (10) prestressed concrete tanks with concrete dome tops and steel shell design with epoxy injection procedure of comparable size demonstrating satisfactory service.

C. The specialty tank contractor's staff shall include a full-time professional engineer having no less than five (5) years of experience in the design and field construction of circular prestressed concrete tanks, who will be the responsible engineer in charge of the work to be done. All working drawings and design calculations shall carry the seal of such professional engineer registered in the State of Georgia.

D. The design and construction of all aspects of the floor, wall, prestressing and walkways of the prestressed concrete tank must be performed by the specialty tank contractor.

E. Prequalification:

1. All tank construction companies must be prequalified and meet the criteria stated in Section 1.04 of this specification to be considered an acceptable tank builder.
2. A complete prequalification package shall be submitted to the Engineer for consideration 21 days prior to the date set for receipt of bids. The prequalification submittal shall include the following items:
   a. Company's last two years financial reports or Balance Sheets and Profit and Loss Statements.
   b. Copy of fully documented Quality Assurance Program.
   c. Company personnel report indicating the following:
      i) Total number of employees by class (Superintendents, Tankbuilders, Nozzlemen, and Laborers) currently employed.
      ii) Number of employees, by class, available for project (state assumed date of construction commencement).
      iii) Number of anticipated temporary employees or new hires to be employed on project.
   d. Complete construction drawings showing the principal sizes, thicknesses, reinforcing size and spacing for all structural members including: floor, wall, dome shell and dome edge.
   e. Complete details of other structural appurtenances as required by the project drawings showing principal sizes, thickness and reinforcing sizes and spacing.
   f. Complete design calculations which address applicable loads provided in project documents.
   g. Experience record for 10 tanks of equal size (or larger) currently serving in the same capacity as the intended use for this project. The record shall include the size of the tank; tank service; name, address and telephone number of the Owner; the year of construction; and the name and telephone number of the Engineer for the project.
   h. Construction schedule which details the duration for tank construction.
3. The following are preapproved as acceptable tank construction companies:
   a. The Crom Corporation, Gainesville, Florida.

1.05 WARRANTY

A. The specialty tank contractor shall guarantee to the Owner the workmanship and materials on the entire tank structure for a period of five (5) years from date of acceptance of the work. In case leakage or other defects appear within the five (5) year period, the specialty tank contractor shall promptly repair the tank at its own expense upon written notice by the Owner that such defects have been found. Defects within the first year shall be considered warranty under the Contractors warranty responsibility. Leakage is defined as a stream flow of liquid appearing on the exterior surface of the tank, or leakage through the base slab, the source of which is from the inside of the tank.

1.06 DESIGN CRITERIA

A. The design shall be in conformance with applicable portions of American Concrete Institute (ACI) 372R-03 Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures, AWWA D110 Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks, and currently accepted engineering principles and practices for the design of such structures.

B. The following loadings shall be utilized in the design:

1. The tank dimensions will be as shown on the contract drawings. The nominal tank working volume is 10 million gallons.
2. Fluid Loads: Shall be the weight of all liquid when the tank is filled to capacity the overflow elevation. The unit weight of the liquid material shall be 62.4 lbs/ft3.
3. Roof Live Loads: Consideration shall be given to all applicable roof design loads in accordance with AWWA D110, Section 3.3 and ASCE 7. The minimum roof live load for the structure shall be 12 psf.
4. Dead Loads: Consideration shall be given to all permanent imposed loads including concrete and steel.
5. Seismic Loads: Seismic load shall be calculated using the effective mass procedure as specified in AWWA D110.
6. Soil Pressure: Earth loads shall be determined by rational methods of soil mechanics. Soil pressure shall not be used in the design of the core wall to counteract hydraulic loads or provide residual compression in the wall.
7. Differential Backfill Loads: Forces from differential backfill loads shall be considered in the design and shall be based on the at-rest coefficient. Passive resistance shall not be used to resist differential backfill loads.
8. Wind Loads: Wind loads shall be considered in the design in accordance with ASCE 7.

PART 2 - PRODUCTS

2.01 CONCRETE

A. Concrete materials shall meet the requirements of ACI 301. Cement shall be Portland Type II or V.

B. Mix proportions shall be in accordance with ACI 301. Concrete or shotcrete in direct contact with prestressed reinforcement shall not contain chloride ions in excess of 0.06 percent of the weight of the cement in the mix.

C. Concrete for floor, footing and dome construction shall have a minimum 28-day strength of 4000 psi. Concrete for wall and walkway construction shall have a minimum 28-day strength of 4000 psi. Concrete cement content, aggregate size, water to cement ratio shall be determined by the tank designer.

D. A maximum of 25% of cementitious material may be fly ash

2.02 SHOTCRETE

A. Shotcrete materials shall meet the requirements of ACI 506. Cement shall be Portland Type II or V. A maximum of 25% of cementitious material may be fly ash.

B. Shotcrete shall have a minimum 28-day strength compressive strength, f'g, of 4000 psi.

C. Wet mix process referred to in ACI 506 for shotcreting shall be used.

D. All shotcrete in contact with diaphragm or prestressing wire shall be proportioned to consist of not more than three parts sand to one part Portland cement by weight. All other shotcrete shall be proportioned to consist of not more than four parts sand to one part Portland cement by weight.

E. Admixtures will not contain more than trace amounts of chlorides, fluorides, sulfides or nitrates.

2.03 REINFORCING STEEL

A. Non-prestressed mild reinforcing steel shall be new billet steel meeting the requirements of ASTM A 185 with a minimum yield strength, fy, of 60,000 psi.

B. Welded wire reinforcing shall be plain wire conforming to the requirements of ASTM A 185 with a minimum yield strength, fy, of 65,000 psi.

2.04 PRESTRESSING STEEL

A. The prestressing wire shall conform to the requirements of ASTM A 821, Type B.

B. The prestressing wire size shall be 0.162" (8 gauge), 0.192" (6 gauge) or larger, but no larger than 0.250".

C. The ultimate tensile strength, fu shall be, 231,000 psi or greater for 8 gauge wire, 222,000 psi or greater for 6 gauge.

2.05 STEEL DIAPHRAGM

A. The steel diaphragm used in the construction of the core wall shall be 26 gauge conforming to the requirements of ASTM A 1008.

B. The steel shell is to be formed with re-entrant angles and erected so that a mechanical key is created between the shotcrete and diaphragm.

C. The sheets of steel diaphragm shall be continuous from bottom to top of wall; horizontal joints or splices will not be permitted.

D. All vertical joints in the diaphragm shall be rolled seamed, crimped and sealed watertight using epoxy injection.

E. In all tanks designed to use a waterstop at the floor/wall joint, the steel shell diaphragm shall be epoxy bonded to the waterstop.

2.06 PVC WATERSTOPS, BEARING PADS AND SPONGE FILLER

A. Plastic waterstops shall be extruded from an elastomeric plastic material of which the base resin is virgin polyvinyl chloride.

B. The profile and size of the waterstop shall be suitable for the hydrostatic pressure and movements to which it is exposed.

C. Bearing pads used in floor/wall joints shall consist of neoprene, natural rubber or polyvinyl chloride.

D. Sponge filler at the floor/wall joint shall be closed-cell neoprene.

2.07 EPOXY

A. Epoxy Sealants:

1. Epoxy used for sealing the steel shell shall conform to the requirements of ASTM C 881.
2. Epoxy used for sealing the steel shell shall be, Type III, Grade 1, and shall be a 100% solids, moisture insensitive, low modulus epoxy system.
3. When pumped, maximum viscosity of the epoxy shall be 10 poises at 77°F.
4. The epoxy sealants used in the tank construction shall be suitable for bonding to concrete, shotcrete, PVC and steel.

B. Bonding Epoxy:

1. Epoxy resins used for enhancing the bond between fresh concrete and hardened concrete shall conform to the requirements of ASTM C 881.
2. Epoxy resins shall be a two-component, 100% solids, moisture-insensitive epoxy and shall be Type II, Grade 2.

2.08 SEISMIC RESTRAINT CABLES

A. When required by design, seismic restraint cables shall be seven-wire strand conforming to ASTM A 416.

B. The strand shall be protected with a fusion-bonded, grit-impregnated epoxy coating conforming to ASTM A 882.

C. The minimum yield strength of the seven-wire strand shall be 270,000 psi.

2.09 ACCESSORIES

A. The specialty tank contractor shall furnish and install those accessories shown on the drawings.

B. Wall Manholes – A minimum of two, 1' 5" x 4' 4" rectangular Type 316 stainless steel wall manhole for access to the interior of the tank shall be provided. The cover and the bolts shall also be of Type 316 stainless steel. The wall manhole shall be designed to resist hydraulic loading without excessive deflection.

C. Wall sleeves shall be constructed of type 316 stainless steel. Tank nozzles shall be of orientation shown on drawings. Wall sleeve shall be provided with circular plate welded around sleeve in the factory.

2.10 COATINGS

A. An exterior coating system shall be provided. Tank coating shall be Tnemec Series 156 Enviro-Crete Modified Waterborne Acrylate. Color to be selected by the Owner.

PART 3 - EXECUTION

3.01 FLOOR

A. The subgrade shall be prepared by fine grading to ensure proper placement of reinforcing steel with proper bottom cover.

B. A 6-mil polyethylene vapor-barrier shall be placed after subgrade preparation has been completed.

C. Form and screed boards shall be of proper thickness and sufficiently braced to ensure that the floor is constructed within proper thickness tolerances.

D. Plate bolsters shall be used to support reinforcing steel in the construction of the floor to ensure positive control of placement of reinforcing steel.

E. The floor shall be vibratory screeded to effect consolidation of concrete and proper encasement of floor reinforcing steel.

F. The floor shall be continuously water cured for a minimum of 7 days.

G. The floor shall receive a light broom finish.

3.02 CORE WALL

A. The wall shall be constructed in a predesigned manner utilizing steel shell diaphragm, layers of shotcrete and prestressing wire with each conforming to the following:

1. Diaphragm Erection:
   a. The diaphragm shall be protected against damage before, during, and after erection. Nail or other holes shall not be made in the steel shell for erection or other purposes except for inserting wall pipes or sleeves, reinforcing steel, bolts, or other special appurtenances. Such penetrations shall be sealed with an epoxy sealant which complies with Section 2.8 Epoxy.

2. Shotcrete:
   a. All shotcrete shall be applied by or under direct supervision of experienced nozzlemen certified by the American Concrete Institute (ACI) as outlined in ACI certification publication CP-60.
   b. Each shotcrete layer shall be broomed prior to final set to effect satisfactory bonding of the following layer.
   c. No shotcrete shall be applied to reinforcing steel or diaphragm that is encrusted with overspray.
   d. No less than ⅛" thick shotcrete shall separate reinforcing steel and prestressing wire.
   e. The steel shell diaphragm shall be encased and protected with no less than 1" of shotcrete in all locations.
3. Curing:
   a. Interior and exterior portions of the shotcrete wall shall be water cured for a minimum of 7 days or until prestressing is started

3.03 EPOXY INJECTION

A. Epoxy injection shall be carried out from bottom to top of wall using a pressure pumping procedure.

B. Epoxy injection shall proceed only after the steel shell has been fully encased, inside and outside, with shotcrete.

3.04 DOME

A. All concrete shall be consolidated by means of a vibrator for proper encasement of reinforcing steel and welded wire fabric.

B. All surfaces at the joint between the wall and the dome shall be coated with bonding epoxy which complies with Section 2.8 Epoxy.

C. Plastic bolsters shall be used to support reinforcing steel and welded wire reinforcement to ensure positive control on placement of steel.

D. The exterior surface of the dome shall receive a light broom finish.

E. The dome shall be water cured for 7 days after casting or until dome band prestressing is completed.

3.05 PRESTRESSING

A. The initial tension in each wire shall be read and recorded to verify that the total aggregate force is no less than that required by the design. Averaging or estimating the force of the wire on the wall shall not be considered satisfactory evidence of correct placement of prestressing wires.

B. Placement of the prestressing steel wire shall be in a continuous and uniform helix of such pitch as to provide in each lineal foot of core wall height an initial force and unit compressive force equal to that shown on the design drawings. Splicing of the wire shall be permitted only when completing the application of a full coil of wire or when removing a defective section of wire.

C. Shotcrete shall be used to completely encase each individual wire and to protect it from corrosion. To facilitate this encasement, the clear space between adjacent wires is to be no less than one wire diameter.

D. Prestressing shall be accomplished by a machine capable of continuously inducing a uniform initial tension in the wire before it is positioned on the tank wall. Tension in the wire shall be generated by methods not dependent on cold working or re-drawing of the wire. In determining compliance with design requirements, the aggregate force of all tensioned wires per foot of wall

shall be considered rather than the force per individual wire, and such aggregate force shall be no less than that required by the design and as shown on approved drawings.

E. The tank construction company shall supply equipment at the construction site to measure tension in the wire after it is positioned on the tank wall. The stress measuring equipment shall include: electronic direct reading stressometer accurate to within 2%, calibrated dynamometers and a test stand to verify the accuracy of the equipment.

F. After circumferential prestressing wires have been placed, they shall be protected by encasement in shotcrete. This encasement shall completely encapsulate each wire and permanently bond the wire to the tank wall.

G. When multiple layers of wire are required, shotcrete cover between layers shall be no less than ⅛" thick.

3.06 COVERCOAT

A. After all circumferential prestressing wires have been placed, a shotcrete cover having a thickness of no less than 1" shall be placed over the prestressing wires.

B. Horizontal sections of the wall shall form true circles without flat areas, excessive bumps or hollows.

C. The covercoat shall receive a sliced trowel finish.

3.07 WALL OPENINGS

A. All wall pipes, sleeves and manholes passing through the wall shall be sealed to the steel shell diaphragm by epoxy injection.

3.08 COATINGS

A. Exterior coatings shall be applied in a minimum of two coats with a thickness of 4.0 to 8.0 MDFT per coat. The minimum total thickness of 10.0 MDFT.

B. All coatings shall be applied a minimum of 28 days after final application of concrete or shotcrete.

C. All application procedures for coatings shall be in accordance with manufacturer's recommendations.

3.09 FIELD QUALITY CONTROL

A. Inspection and Testing:

1. Concrete and Shotcrete Testing:
   a. Compression Tests:
      iv) Compression test specimens shall be taken during construction from the first placement of each class of concrete specified herein and at intervals thereafter as selected by the Engineer to insure continued compliance with these Specifications. At least one set of test specimens shall be made for each 150 yards of concrete placed and each 75 yards of shotcrete placed. Each set of test specimens shall be a minimum of 5 cylinders.
      v) Compression test specimens for concrete/shotcrete shall conform to ASTM C 172 for sampling and ASTM C 31 for making and curing test cylinders. Test specimens shall be 6-inch diameter by 12-inch high or 4-inch diameter by 8-inch high cylinders.
      vi) Compression test shall be performed in accordance with ASTM C 39. Two test cylinders will be tested at 7 days and two at 28 days. The remaining cylinder will be held to verify test results, if needed.
   b. Air Content Tests:
      i) Air content tests shall conform to ASTM C 231 (Pressure Method for Air Content).
      ii) Tests for air content shall be made prior to concrete placement and whenever compression test specimens are made.
   c. Slump Tests:
      i) Slump tests shall be made in accordance with ASTM C 143.
      ii) Slump tests shall be made whenever compression test specimens are made.
2. Hydrostatic Testing:
   a. On completion of the tank and prior to completion of backfill placement at the footing or wall, the tank shall be tested for watertightness.
   b. The testing for watertightness shall be completed as follows:
      i) Fill the tank with water to the maximum water level and let it stand for a minimum of 24 hours.
      ii) Measure the drop in liquid level over the next 72 hours to determine the liquid volume loss for comparison with the allowable leakage. Evaporative losses shall be measured or calculated and deducted from the measured loss to determine the net liquid loss (leakage). The net liquid loss for a period of 24 hours shall not exceed 0.05 of 1 percent of the tank capacity.
      iii) If the leakage exceeds the maximum allowable, the leakage test shall be extended to a total of five (5) days. If at the end of five (5) days the average daily leakage does not exceed the allowable, the test shall be considered satisfactory. If the net liquid loss exceeds the maximum allowable, leakage shall be considered excessive and the tank shall be repaired and retested until leakage falls within the appropriate limits.
      iv) Damp spots on the exterior wall surface or measurable leakage of water at the wall base shall not be permitted. Damp spots are defined as spots where moisture can be picked up on a dry hand. The source of water movement through the wall shall

be located and permanently sealed in an acceptable manner. Leakage through the wall-base joint or footing shall likewise be corrected. Damp spots on the footing are generally to be expected, and are permissible.

3.10 CLEANING

A. The interior of the tank shall be cleaned to remove debris, construction items, and equipment prior to testing.

END OF SECTION 03414

SECTION 03450
ARCHITECTURAL PRECAST CONCRETE

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Decorative trim for installation in masonry.
2. Pre-cast concrete coping.
3. Connection devices.

B. Products furnished but not installed under this section:

1. Anchors for connecting precast concrete elements to structural framing.

C. Related Sections:

1. Cast-in-place concrete: Elsewhere in Division 3.
2. Joint sealers: Division 7.
3. Masonry: Division 4.

1.02 SUBMITTALS

A. Product Data: Submit fabricator's specifications, data, and instructions for manufactured materials and products, including the following:

1. Mix designs.
2. Test results for compressive strength.
3. Water absorption test results for exterior units.

B. Shop Drawings: Include complete information essential to proper fabrication and installation of precast units. Show dimensions, fabrication tolerances, and reinforcement sizes and locations, including locations and types of lifting devices required.

1. Show location of precast units and identification of each, corresponding to planned sequence of installation.
2. Designate welded connections by means of standard AWS symbols.
3. Provide locations and details of anchorages for installation in other work; furnish templates if required for accuracy.
4. Provide design calculations prepared by a professional structural engineer registered in the state in which the project is located.

C. Samples: Precast concrete panels not less than 12 inches square, illustrating finish color, quality, and texture.

1.03 QUALITY ASSURANCE

A. Codes and Standards: Comply with provisions of the following, except where exceeded by other requirements of the contract documents or of governing authorities:

1. ACI 301.
2. ACI 318.
3. ANSI/AWS D1.4.
4. CRSI Manual of Standard Practice.
5. PCI MNL-116.
6. PCI MNL-117.

B. Fabricator Qualifications:

1. Producer member of the Prestressed Concrete Institute (PCI) or participant in PCI's Plant Certification Program.

C. Fabrication Requirements:

1. Design units to support loads indicated and as required by applicable code requirements.
2. Produce required units at precast concrete fabricating plant; site-produced units are not acceptable.

D. Erector Qualifications: Firm with not less than 5 years of experience in the successful erection of precast units comparable to those specified.

E. Mock-ups: Prepare one full-size sample of each precast concrete unit type and erect on project site for the Architect/Engineer's inspection and approval prior to start of fabrication.

1. Patching: Damage an area on exposed face surface and demonstrate to the Architect/Engineer materials and methods proposed for minor repairs. If demonstration is acceptable to the Architect/Engineer, repairs matching approved sample repair will be allowed in the work. Otherwise, removal and replacement of damaged units will be required.
2. When directed by the Architect/Engineer, remove mock-ups from project site; they may not be incorporated in the work.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver precast concrete units to ensure continuity of installation. Store to prevent damage such as cracking, distortion, or staining, and to maintain visibility of markings. Handle and support units using only designated lift points and lifting devices.

PART 2 - PRODUCTS

2.01 FORMWORK

A. General: Construct forms accurately to size, mortar-tight, and of sufficient strength to withstand all fabrication operations without distortion of precast units.

B. Tolerances: Maintain formwork to provide finished units within fabrication tolerances specified in PCI MNL-116.

C. Facing Materials, General: Provide form facings of metal, plastic, or other nonreactive material that will produce required concrete finish.

2.02 REINFORCING MATERIALS

A. Reinforcing Bars: ASTM A 615, Grade 60, deformed except where plain bars are indicated.

B. Steel Wire: ASTM A 82, plain cold-drawn.

C. Welded Wire Fabric: ASTM A 185, plain cold-drawn steel.

D. Reinforcing Accessories:

1. Tie wire: Black annealed type, 16-1/2 gage or heavier.
2. Supports: Bar supports conforming to specification of CRSI's Manual of Standard Practice.
   a. Class 1 (plastic protected) at all formed surfaces which will be exposed to weather.
   b. Class 1 (plastic protected) or Class 2 (stainless steel protected) at all formed surfaces which will be exposed to view but not to weather.

2.03 CONCRETE MATERIALS

A. Portland Cement: ASTM C 150, and as follows:

1. Type I or Type III, except where other type is specifically permitted or required by the contract documents.

B. Aggregates:

1. Normal weight: ASTM C 33.
2. Structural lightweight concrete: ASTM C 330.

C. Water: Potable.

D. Admixtures - General: Admixtures which result in more than 0.1 percent of soluble chloride ions by weight of cement are prohibited.

E. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other admixtures specified.

F. Water-Reducing Admixture: ASTM C 494, Type A.

G. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

H. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.

I. High-Range Water-Reducing Admixture (Superplasticizer): ASTM C 494, Type F or G.

2.04 CONNECTION MATERIALS

A. Steel Welding Plates: ASTM A 283; Grade C, structural quality.

B. Steel Shapes: ASTM A 36.

C. Steel Finish: Hot-dip galvanize after fabrication components that will be exposed to weather, in accordance with ASTM A 153. Components that are cast into precast units and exposed to view but not to weather may be cadmium coated, electro-galvanized, or hot-dip galvanized. Other steel components may be coated with fabricator's standard rust inhibitor paint.

D. Anchor Bolts: ASTM A 307, Grade C.

E. Welding Electrodes and Fluxes: AWS D1.1, types as required by materials being welded.

F. Accessories: Hangers, clips, and other items required for installation of precast units and support of related construction.

2.05 CONCRETE MIX DESIGN

A. General: Prepare design mix of concrete on the basis of either field experience or trial mixtures, as specified in ACI 301.

B. Review: Do not begin concrete production until proposed mix has been reviewed by the Architect/Engineer.

C. Mix: Design mix to achieve properties of concrete as follows:

1. Compressive strength: 6000 psi minimum at 28 days.

D. Mix Adjustments: Provided that no additional expense to owner is involved, Contractor may submit for Architect/Engineer approval requests for adjustment to approved concrete mixes when circumstances such as changed project conditions, weather, or unfavorable test results occur. Include laboratory test data substantiating performance characteristics with mix adjustment requests.

E. Admixtures:

1. Air-entraining admixture: Use in accordance with ACI 301 for maximum size of coarse aggregate.
2. Water-reducing admixtures: Use in strict compliance with manufacturer's directions and in amounts suitable for weather conditions prevailing at time of placement.

2.06 FABRICATION

A. General: Fabricate architectural precast concrete units in compliance with PCI MNL-117. Adequately reinforce units to resist stresses due to transporting and handling.

B. Built-in Anchorages: Locate accurately and secure to formwork. Position to avoid interference with main reinforcement or placement of concrete; do not relocate without the Architect/Engineer approval.

C. Openings: Cast openings with minimum dimension of 10 inches or larger. Smaller openings may be field cut as required, with the Architect/Engineer prior approval.

D. Release Agent: Provide either form materials with permanent factory-applied nonabsorptive liner or form coating. If form coating is used, thoroughly clean and recondition formwork and reapply coating before each use. Rust on form surfaces is unacceptable.

E. Reinforcement: Clean reinforcement of loose rust and mill scale, soil, and other materials which adversely affect bond with concrete. Place reinforcement to achieve not less than minimum concrete coverages required for protection, and accurately position, secure, and support against displacement. Set wire ties completely embedded in concrete without contact with or penetration of exposed concrete surfaces.

F. Concrete: Place continuously for each unit, complying with requirements of ACI 304. Consolidate concrete by vibration while avoiding damage to or dislocation of reinforcement, anchorages, and built-in accessories.

G. Identification: Mark units to identify pickup points and final orientation, corresponding to final shop drawings. Imprint fabrication date on each unit in concealed location.

H. Architectural Finish: Fabricate exposed faces of architectural precast concrete units to achieve finish as follows:

1. Smooth, off-the-form finish, free of pockets, sand streaks, and other surface blemishes.
2. Match Architect/Engineer's control samples.

I. Provide as-cast or float finish for surfaces which will be concealed.

2.07 SOURCE QUALITY CONTROL

A. Non-Conforming Work: Replace precast concrete units which do not conform to specified requirements, as directed by the Architect/Engineer and pay for corrections to other work necessitated by such replacement.

1. Dimensions: Precast concrete units smaller than allowed by specified tolerances will be rejected. Units larger than specified tolerances will be rejected if they interfere with other construction or if, in the opinion of the Architect/Engineer, the appearance of the work is adversely affected.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Comply with erection recommendations of PCI MNL-127. Provide temporary shoring, bracing, and connections as required to maintain stability of structure and precast units during construction, arranged to avoid interference with subsequent precast unit installation.

B. Anchor Bolts: Clean bearing and contact surfaces before assembly. Set precast units with bearing plates accurately, using wedges, shims, or setting nuts as required. After tightening anchor bolts and ensuring that members are plumb, grout solidly between plates and bearing surfaces.

C. Welding: Comply with requirements of AWS D1.1.

1. Protect adjacent concrete surfaces from damage due to weld splatter, smoke staining, or excessive heat that can lead to spalling, using noncombustible shields.
2. Remove slag and coat metal surfaces affected by welding immediately after completing welding in each area. Use zinc-rich coating for galvanized connections and a good quality rust inhibitive primer for non-galvanized connections.

D. Erection Tolerances: Do not exceed tolerance limits specified in PCI MNL-127.

E. Grouting Joints: Grout open joints after precast units have been placed, properly aligned, and permanently secured in position. Use formwork if required to avoid leaks and maintain grout in proper position until it has cured. Strike off unformed grout surfaces flush with adjacent surfaces. Do not allow grout to dry prematurely.

3.02 FIELD QUALITY CONTROL

A. General: Conduct inspections, perform testing, and make repairs or replace unsatisfactory precast units as required. The Architect/Engineer may reject architectural precast panels for any of the following reasons:

1. Specified tolerances exceeded.
2. Damage to panels.
   a. Patching of damage to exposed faces is subject to the Architect/Engineer's approval.
3. Surface finish deficiencies in exposed faces.
4. Other defects as listed in PCI MNL-117.

3.03 CLEANING

A. Clean exposed faces of precast units after all joint treatment has been completed, following recommendations of precast fabricator. Provide protection to adjacent surfaces which could be damaged by cleaning materials or methods.

END OF SECTION 03450

SECTION 03600
GROUT

PART 1 - GENERAL

1.01 SCOPE

A. Contractor shall furnish all labor, materials, equipment, and incidentals required to provide grout as shown and specified.

B. Grout shall be placed at the following locations:

1. Pipe Railing.
2. Dowelling.
3. Weir and Slide Gates.
4. Grating.
5. Concrete Patchwork.
6. Anchor Bolts.
7. Waterstops.
8. Precast to concrete structures.
9. Under baseplates.

C. The types of grout include the following:

1. Non-shrink, epoxy type.
2. Non-shrink, non-metallic type.
3. Ordinary cement-sand.
4. Refer to Section 03300 for pressure grouting applications.

1.02 SUBMITTALS

A. Shop Drawings: Submit copies of manufacturer's specifications and installation instructions for all proprietary materials.

B. Reports and Certificates:

1. For proprietary materials, submit copies of reports on quality control tests.
2. For nonproprietary materials, submit certification that materials meet specification requirements.

1.03 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.

1. ASTM C 150, Portland Cement.

2. ASTM C 109, Compressive Strength of Hydraulic Cement Mortars (using 2-in. or 50 mm. Cube Specimens).
3. ASTM C 191, Time of Setting of Hydraulic Cement by Vicat Needle.
4. CRD-C 588, Specifications for Non-Shrink Grout.

1.04 PRODUCT DELIVERY. STORAGE AND HANDLING

A. Delivery of Materials: Grout materials from manufacturers shall be delivered in unopened containers and shall bear intact manufacturer's labels.

B. Storage of Materials: Grout materials shall be stored in a dry shelter and shall be protected from moisture.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Non-metallic, cartridge style, 100 percent solids, high strength epoxy grout.

1. Product and Manufacturer: Speed Bond #1 as manufactured by Prime Resins Inc.
2. Hilti.
3. Simons.
4. Red Head.
5. Or Equal.

B. Non-Shrink, Non-Metallic Grout

1. Pre-mixed non-staining cementitious grout requiring only the addition of water at the jobsite meeting ASTM C-827 and CRD C-621.
2. Product and Manufacturer:
   a. Sikagrout 212 by Sika Corp.
   b. Masterflow 713 by Master Builders Company.
   c. Non-Ferrous Non-Shrink Grout by the Burke Company.
   d. Non-Shrink, Non-Metallic Grout as manufactured by W. R. Meadows.
   e. Or Equal.

C. Ordinary Cement-Sand Grout:

1. Except where otherwise specified use 1 part cement to 3 parts sand complying with the following:
   a. Cement: ASTM C 150, Type II.
   b. Sand: ASTM C 33.
2. For water repelling and shrinkage reducing requirements use admixtures.
   a. Product and Manufacturer:
      i) Integral Waterpeller by The Euclid Chemical Company.
      ii) Omicron, Type OM by Master Builders Company.

iii) Hydrocide Powder by Sonneborn-Contech.

iv) Or Equal.

3. For use at horizontal waterstops only.

D. Water: Use clean, fresh, potable water free from injurious amounts of oils, acids, alkalies or organic matter.

E. Epoxy Resin Adhesive:

1. Two part mix 1:1.
2. Hilti.
3. Simons.
4. Red Head.
5. Manufacturer: Sika Corp - Sikadur 32, Hi-Mod (Horizontal joints), Sikadur 31 Hi-Modgel (Vertical joints) or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General

1. Place grout as shown and in accordance with manufacturer's instructions. If manufacturer's instructions conflict with the Specifications do not proceed until Engineer provides clarification.
2. Drypacking will not be permitted unless approved by the Engineer.
3. Manufacturers of proprietary products shall make available upon 72 hours notification the services of a qualified, full time employee to aid in assuring proper use of the product under job conditions.
4. Placing grout shall conform to temperature and weather limitations in Section 03300.
5. Surface to be grouted is to be adequately cured, cleaned dampened and roughened per manufacturer recommendations to ensure adequate bonding.

B. Pipe Railings

1. After posts have been properly inserted into the holes or sleeves, fill the annular space between posts and sleeve with the non-shrink, non-metallic grout. Bevel grout at juncture with post so that moisture flows away from post.
2. Do not grout railing designated as "removable sections".

C. Grout for Dowelling and Anchor Bolts

1. Epoxy resin Adhesive may be used in accordance with manufacturer's recommended application.
2. Reference Section 03605.

D. Grouting for Waterstops

1. Grout for PVC waterstops to be the non-shrink, non-metallic type. Refer to Section 03250 for installation procedures.
2. Grout from Redi-mix plant conforming to applicable requirements of Section 03300 may be substituted at no additional compensation to the Contractor.

E. Grouting for Weir and Slide Gates: Provide minimum of 1" thickness of non-shrink, non-metallic grout under frames. Gates to be coated with an approved epoxy coating per Section 09900 prior to installing and grouting.

F. Grouting for Bearing Plates and Equipment: Use non-shrink, non-metalic grout for setting bearing plates and equipment. Provide a minimum grout thickness of 1".

G. Patchwork at Demolition Areas

1. Furnish and install non-shrink, non-metallic grout for dry packing as required to patch all mechanical, electrical and miscellaneous penetrations which are either designated to be patched or are the result of abandoned, removed or relocated material and equipment. Prepare surface and place grout as recommended by manufacturer and as specified. Finish grout off flush with existing surface.
2. Reinforce with approved wire mesh and use approved structural concrete for penetrations larger than 1/2 square feet. Conform to requirements of Sections 03100, 03200 and 03300.

END OF SECTION 03600

SECTION 03605
DOWELING INTO EXISTING CONCRETE

PART 1 - GENERAL

1.01 SCOPE

A. Contractor shall furnish all labor, materials, equipment and incidentals required to place reinforcing dowels into existing concrete using a two-component epoxy adhesive as shown and specified.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Product Data: Furnish technical data for epoxy adhesives, grouts, and bonding agents suggested for the Project work including installation instructions, independent laboratory test results, and handling and storage instructions.

B. Samples: Furnish two random samples of each batch of products delivered to Project site, for independent testing.

C. Quality Control Submittals: Furnish the following:

1. Manufacturer's past project experience data on at least three similar projects supplied with proposed products within the last 3 years, to include client name, address, contact person, phone number, project location, and description of work.
2. Batch test reports for each batch of product delivered to site. Provide manufacturer's written certification that each batch delivered meets these Specifications, the intended uses on project, including capability to bond to damp or wet concrete surfaces. Certification shall include batch test results for each product.
3. Manufacturer's written letter of certification identifying Contractor's employees qualified for operation of manufacturer's equipment and certified for installation of products, trained through jobsite instruction conducted by manufacturer.
4. Copy of manufacturer's equipment service and repair manuals for each type of equipment delivered to project site.
5. Copy of manufacturer's service agreement with Contractor for each type of equipment.
6. Procedures for testing and verifying product meets specified requirements.
7. Special Inspection: Provide detailed step-by-step instructions for the special inspection procedure as required by ICBO reports and Section 306 of the Uniform Building Code.

1.03 QUALITY ASSURANCE

A. Contractor shall examine the conditions under which reinforcing dowels are to be placed into existing concrete, and notify the Engineer in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

B. Reference Standards: Comply with applicable provisions and recommendations of the latest edition of the following, except as otherwise shown or specified:

1. ACI 301, Specifications for Structural Concrete For Buildings.
2. ACI 305, Hot Weather Concrete.
3. ACI 318, Building Code Requirements for Reinforced Concrete.
4. ACI 350, Environmental Engineering Concrete Structures.
5. ACI 347, Recommended Practice for Concrete Formwork.
6. ICBO Report No. 4398, April 1988 for Adhesive Technology Corp.

1.04 MANUFACTURERS' SERVICES

A. Furnish manufacturer's representative to conduct jobsite training for proper installation, handling, and storage of each product delivered to Project site, for personnel who will perform actual installation. Engineer will attend training sessions.

PART 2 - PRODUCTS

2.01 GENERAL

A. Items of Materials: End products should be from one manufacturer in order to achieve structural compatibility, singular responsibility, and standardization for maintenance, and replacement.

B. Epoxy Adhesive for Doweling

1. Meet ASTM C 881, Type 1, Grade 3, Class A, B, or C, depending on site conditions.
2. Hilti.
3. Sika.
4. Two-component, 100 percent solids, nonsag, paste, insensitive to moisture, designed to be used in adverse freeze/thaw environments and gray in color.
5. Cure Temperature, Pot Life, and Workability: Compatible for intended use and environmental conditions.
6. Container Markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precaution.

C. Component "A" Base Resin

1. Modified biphenyl-A type epoxy.
2. Viscosity: Light paste, 350 cps maximum prior to mixing to ensure proper wetting of moist concrete surfaces.
3. Fillers: 100 percent solids, fumed silica and selected annular micro silica powders. Do not use micro spheres, fly ash, or asbestos.
4. Color: White.

D. Component "B" Hardener or Curing Agent

1. Viscosity: Light paste.
2. Fillers: 100 percent solids, fumed silica and selected annular micro silica powders. Do not use micro spheres, fly ash, or asbestos.
3. Color: Black.

E. Mixed Epoxy Adhesive

1. Nonsag light paste consistency with ability to remain in a 1-inch diameter overhead drilled hole without runout, holding the following properties:
   a. Slant Shear Strength, ASTM C 881/882, No Failure in Bond Line, Dry/Moist Conditions: 5,000 psi.
   b. Compressive Strength, ASTM D 695: 14,000 psi, minimum.
   c. Tensile Strength, ASTM D 695: 4,500 psi.
   d. Heat Deflection Temperature, ASTM D 648: 135 degrees F, minimum.
2. Manufacturers:
   a. Adhesives Technology Corp, 4210 B Street, N.W., Suite D, Auburn, WA 98001, Anchor-It Fastening Systems, HS 200 Epoxy Resin, telephone 1-800-262-4748.
   b. Or equal.

PART 3 - EXECUTION

3.01 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Storage of Epoxy Components:

1. Store epoxy components on pallets or shelving in a covered storage area with locking door.
2. Control temperature above 60 degrees F and dispose of product if shelf life has expired.
3. If stored at temperatures below 60 degrees F, test components prior to use to determine if they still meet specified requirements.

3.02 GENERAL

A. Dispensing, Metering, or Mixing Epoxy Adhesive Components: Use portable, automatic metering and mixing device or machine capable of maintaining prescribed mix ratio within deviation of 5 percent or less, by volume.

B. Dispense epoxy components through specially designed static mixing nozzle that thoroughly mixes epoxy components and places mixed epoxy at base of predrilled hole.

C. Mixing Nozzles: Disposable, manufactured in several sizes to accommodate size of reinforcing dowels.

D. Where large meter and mixing pumps are impractical, provide epoxy adhesive packaged as follows:

1. Disposable, self-contained cartridge system capable of dispensing both epoxy components in the proper mixing ratio, and fit into a manually or pneumatically operated caulking gun.
2. Dispense components through a mixing nozzle that thoroughly mixes components and places epoxy at base of predrilled hole.
3. Mixing Nozzles: Disposable, manufactured in several sizes to accommodate sizes of reinforcing dowels.

3.03 TESTING OF AUTOMATIC METERING AND MIXING DEVICES

A. Tests for Proper Ratio:

1. Retain small amount of dispensed adhesive for inspection after each time the pump is refilled.
2. Operator shall check these samples for color change.
3. Should change in color occur, operator shall follow manufacturer's service instructions to obtain proper operation.

B. Frequency of Tests: Make full ratio check after each 100 gallons of adhesive is dispensed or if color of mixed adhesive becomes noticeably darker or lighter.

C. Ratio Check Procedure:

1. Disconnect dispensing head behind ON/OFF valve.
2. Place a 1-cup volume container and a 2-cup volume container under the "B" and "A" component hose ends.
3. Actuate the pump until both cups are filled to a proper proportion of 2:1 by volume.

3.04 DOWEL SIZING AND INSTALLATION

A. Drilling Equipment:

1. Drilling Hammers for Dowel Holes: Electric or pneumatic rotary type with medium or light impact.
2. Hollow drills with flushing air systems are preferred.
3. Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.

B. Hole Diameter

1. As small as possible to allow dowel to be embedded to required depth.
2. Use drill bit diameter meeting ICBO report requirements.
3. Hole Diameter: Dowel diameter plus 1/8 inch for temperature at time of installation above 60 degrees F, or dowel diameter plus ¼ inch for temperature at time of installation below 60 degrees
4. For large reinforcing bars No. 8 or greater embedded 18 diameters or more, verify hole diameter with manufacturer.

C. Obstructions in Drill Path

1. When existing reinforcing steel is encountered during drilling and when approved by the Engineer, enlarge the hole by 1/8 inch, core through the existing reinforcing steel at the larger diameter, and resume drilling at original hole diameter; or redrill hole 1 inch from original location, beginning in the same line at the surface, redirecting the drill to miss reinforcing steel.
2. Place dowels in both the misdrilled hole and the new one.
3. Dowels may be prebent prior to installation to 15 degrees to align with other bars. Do not heat dowels to bend.
4. If bars have fused epoxy coating and coating is damaged, recoat damaged area with epoxy.
5. Bent Bar Dowels: Where edge distances are critical, and striking reinforcing steel is likely, drill hole at 10 degree angle or less and use prebent reinforcing bars.
6. Conform to details shown.
7. Do not install prior to receiving manufacturer onsite training.

D. Dowel Embedment Depth: Install to depth and spacings shown.

END OF SECTION 03605