

**PART 1 – GENERAL****1.01 DESCRIPTION**

- A. The WORK specified in this Section includes the requirements for furnishing, installing, and removal of concrete formwork, falsework, and formwork support as designated in the Contract.

**1.02 DEFINITIONS**

- A. References
  - 1. American Concrete Institute (ACI)
    - a. 117 - Standard Specifications for Tolerances for Concrete Construction and Materials
    - b. 318 - Building Code Requirements for Reinforced Concrete
    - c. 347 - Formwork for Concrete

**1.03 SUBMITTALS**

- A. Provide submittals in accordance with the requirements of Section 01300, SUBMITTAL PROCEDURES, and additional requirements in this Section.
- B. Shop Drawings
  - 1. Wall forming system concept drawings.
  - 2. Form Ties-Tapered Through-Bolts; proposed method of sealing form tie hole; coordinate with details shown.
  - 3. Formwork, falsework, and shoring design calculations for all elevated slab and beam construction.
  - 4. Form release agent.
- C. Samples: As follows:
  - 1. Form ties, one sample.
- D. Quality Control Submittals: Statement of qualification for formwork designer.

**1.04 DESIGN REQUIREMENTS**

- A. Formwork Designer: Provide formwork, falsework, and shoring design by an engineer licensed in the State of Oregon.

- B. Design formwork in accordance with ACI 347 and ACI 318 to provide concrete finishes specified in Section 03300, CAST-IN-PLACE CONCRETE.
- C. When high range water reducer (superplasticizer) is used in concrete mix, design forms for full hydrostatic pressure per ACI 347.
- D. Make joints in forms watertight.
- E. Limit panel deflection to 1/360th of each component span to achieve tolerances specified.

**PART 2 – PRODUCTS****2.01 EQUIPMENT (NOT USED)****2.02 MATERIALS**

- A. Wall Forms and Underside of Slabs and Beams
  - 1. Plywood, hard plastic finished plywood, overlaid waterproof particle board, or steel in "new and undamaged" condition, of sufficient strength and surface smoothness to produce specified finish.
  - 2. Circular Structures
    - a. Conform forms to circular shape of structure.
    - b. Straight panels may be substituted for circular forms provided panels do not exceed 2 feet in horizontal width and angular deflection is no greater than 3-1/2 degrees per joint.
- B. Column Forms
  - 1. Rectangular Columns: As specified for walls.
  - 2. Circular Columns: Fabricated steel or fiber reinforced plastic with bolted together sections or spirally wound laminated fiber form internally treated with release agent for height of column.
- C. All Other Forms: Materials as specified for wall forms.
- D. Stay in place forms will not be allowed without prior approval by the OWNER'S REPRESENTATIVE.
- E. Form Release Agent
  - 1. Material: Do not use release agents that bond with, stain, or adversely affect concrete surfaces, and impair subsequent treatments of concrete surfaces when applied to forms. Use a ready-to-use water, vegetable oil, or mineral oil based

material formulated to reduce or eliminate surface imperfections, containing no organic solvents and that meets local, state, and federal regulations.

2. Manufacturers and Products
  - a. Master Builders, Inc.; Rheofinish
  - b. Cresset Chemical Company; Crete-Lease 20-VOC
  - c. Or approved equal.
- F. Rustication Grooves and Beveled Edge Corner Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.
- G. Form Ties
  1. Material: Steel.
  2. Spreader Inserts
    - a. Conical or spherical type.
    - b. Design to maintain positive contact with forming material.
    - c. Furnish units that will leave no metal closer than 1 inch to concrete surface when forms, inserts, and tie ends are removed.
  3. Wire ties not permitted.
  4. Flat bar ties for panel forms, furnish plastic or rubber inserts with minimum one inch depth and sufficient dimensions to permit patching of tie hole.
  5. Water Stop Ties: For water-holding structures, shaft walls, basements, pipe galleries, and accessible spaces below finish grade, furnish one of the following:
    - a. Integral steel water stop 0.103 inch thick and 0.625 inch in diameter tightly and continuously welded to tie.
    - b. Neoprene water stop 3/16 inch thick and 15/16 inch in diameter whose center hole is 1/2 diameter of tie, or molded plastic water stop of comparable size.
    - c. Orient water stop perpendicular to tie and symmetrical about center of tie.
    - d. Design ties to prevent rotation or disturbance of center portion of tie during removal of ends and to prevent water leaking along tie.

6. Through-Bolts: Tapered minimum 1 inch diameter at smallest end.
7. Elastic Vinyl Plug
  - a. Design and size plug to allow insertion with tool to enable plug to elongate and return to original length, and diameter upon removal forming watertight seal.
  - b. Manufacturer and Product: Dayton/Richmond Co., Miamisburg, OH; A58 Sure Plug, or approved equal.

**PART 3 – EXECUTION****3.01 PREPARATION**

- A. Thoroughly clean form surfaces that will be in contact with concrete or that have been in contact with previously cast concrete, dirt, and other surface contaminants prior to coating surface.
- B. Exposed Wood Forms in Contact with Concrete: Apply form release agent as recommended by the manufacturer.
- C. Steel Forms: Apply form release agent to steel forms as soon as they are cleaned to prevent discoloration of concrete from rust.

**3.02 INSTALLATION**

- A. General: Unless specified otherwise, follow applicable recommendations of ACI 347.
- B. Beveled Edges (Chamfer)
  1. Form 3/4 inch bevels at concrete edges, unless otherwise shown.
  2. Where beveled edges on existing adjacent structures are other than 3/4 inch, obtain OWNER'S REPRESENTATIVE approval of size prior to placement of beveled edge.
- C. Wall Forms
  1. Do not reuse forms with damaged surfaces.
  2. Locate form ties and joints in an uninterrupted uniform pattern.
  3. Inspect form surfaces prior to installation to assure conformance with specified tolerances.

- D. Forms for Curbs, Sidewalks, and Driveways
1. Provide standard steel or wood forms.
  2. Set forms to true lines and grades, and securely stake in position.
- E. Form Tolerances: Provide forms in accordance with ACI 117, 347 and 318 and the following tolerances for finishes specified:
1. Wall Tolerances
    - a. Straight Vertical or Horizontal Wall Surface: Flat planes within tolerance specified.
    - b. Wall Type W-A
      - 1) Plumb within 1/4 inch in ten feet or within one inch from top to bottom for walls over 40 feet high.
      - 2) Depressions in Wall Surface: Maximum 5/16 inch when ten foot straightedge is placed on high points in all directions.
    - c. Wall Type W-B
      - 1) Plumb within 1/8 inch in ten feet or within 1/2 inch from top to bottom for walls over 40 feet high.
      - 2) Depressions in Wall Surface: Maximum 1/8 inch when ten foot straightedge is placed on high points in all directions.
    - d. Thickness: Maximum 1/4 inch minus or 1/2 inch plus from dimension shown.
    - e. Form Offset: Between adjacent pieces of formwork, facing material shall not exceed 1/4 inch.
  2. Beams and Columns Tolerances
    - a. Exposed Straight Horizontal and Vertical Surfaces: Flat planes within tolerances specified.
    - b. Lateral Alignment
      - 1) Centerlines must be within plus or minus 1/2 inch from dimensions shown.
      - 2) At intersections, centerlines shall intersect within plus or minus 1/2 inch of dimensions shown.

- c. Beam Type B-A
  - 1) Physical Dimensions: Maximum 1/4 inch minus or 1/2 inch plus from dimension shown.
  - 2) Elevations: Within plus or minus 1/2 inch, except where tops of beams become part of finished slab. In this case refer to slab tolerances.
- d. Column Type C-A
  - 1) Physical Dimensions: Maximum 1/4 inch minus or 1/2 inch plus from dimension shown.
  - 2) Plumb within 1/4 inch in ten feet in all directions with maximum 1/2 inch out-of-plumb at top with respect to bottom.

**3.03 FORM REMOVAL**

- A. Non-supporting forms (sides of beams, walls, columns, and similar parts of WORK) may be removed after cumulatively curing at not less than 50 degrees F for 24 hours from time of concrete placement if:
  - 1. Concrete is sufficiently hard so as not to sustain damage by form removal operations, and
  - 2. Curing and protection operations are maintained.
- B. Elevated Structural Slabs or Beams: In accordance with ACI 318, Chapter 6, and at such time as concrete has reached compressive strength equal to 80 percent of specified 28 day compressive strength as determined by test cylinders.

**END OF SECTION**

**PART 1 – GENERAL**

**1.01 DESCRIPTION**

- A. The WORK in this section includes the requirements for furnishing, fabricating, and installing reinforcing steel, mechanical splices, and accessories as designated in the Contract.

**1.02 DEFINITIONS**

A. References

1. American Concrete Institute (ACI)
  - a. 318 – Building Code Requirements for Reinforced Concrete and Commentary.
  - b. SP-66 – Detailing Manual.
2. American Society for Testing and Materials (ASTM)
  - a. A82 – Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
  - b. A185 – Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
  - c. A497 – Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.
  - d. A615 – Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
  - e. A706 – Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
  - f. A767 – Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
3. American Welding Society (ANSI/AWS)
  - a. D1.4 – Structural Welding Code, Reinforcing Steel
4. Concrete Reinforcing Steel Institute (CRSI).
  - a. Placing Reinforcing Bars
  - b. Manual of Standard Practice

5. International Conference of Building Officials (ICBO)
  - a. ICBO Research Report

**1.03 SUBMITTALS**

- A. Provide submittals in accordance with the requirements of Section 01300, SUBMITTAL PROCEDURES, and additional requirements in this Section.
- B. Shop Drawings
  1. Prepare in accordance with CRSI Manual of Standard Practice and ACI SP-66 Detailing Manual:
    - a. Bending lists.
    - b. Placing drawings.
  2. Welded, metallic sleeve splice, and mechanical threaded connection.
- C. Quality Control Submittals
  1. Lab test reports for reinforcing steel showing stress-strain curves and ultimate strengths.
  2. Mechanical Threaded Connections
    - a. Current ICBO Research Report or equivalent code agency report listing findings to include acceptance, special inspection requirements, and restrictions.
    - b. Manufacturer's instructions.
    - c. Verification that device threads have been tested and meet requirements for thread quality, in accordance with manufacturer's published methods.
  3. Welding Qualification: Prior to welding, submit welder qualifications and nondestructive testing procedures in accordance with AWS D1.4.
  4. Test results of field testing.

**1.04 QUALITY ASSURANCE**

- A. Welder Qualifications: Certified in accordance with AWS D1.4.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Unload, store, and handle bars in accordance with CRSI publication "Placing Reinforcing Bars."

**PART 2 – PRODUCTS****2.01 EQUIPMENT (NOT USED)****2.02 MATERIALS**

- A. Deformed Billet-Steel Reinforcing Bars
  - 1. Includes stirrups, ties, and spirals.
  - 2. ASTM A615, Grade 60, where welding is not required.
  - 3. ASTM A706, Grade 60, for reinforcing to be welded.
  - 4. ASTM A767, Grade 60, for galvanized bars.
- B. Mechanical Splices and Connections
  - 1. Provide in accordance with the requirements of Section 03212, REINFORCING BAR COUPLERS.
- C. Thread Bars
  - 1. Provide thread bars having a continuous rolled-in pattern of thread-like deformations along the entire length.
  - 2. Provide hex nuts and couplers for the thread bars that develop 125 percent of yield strength of the bar.
  - 3. Conform to the requirements of ASTM A615, Grade 60.
  - 4. Manufacturers: Use the following, or equal:
    - a. DYWIDAG Systems International, Long Beach California, DYWIDAG Threadbar.
  - 5. Do not substitute cut threads on regular reinforcing bars for thread bars.
- D. Welded Wire Fabric
  - 1. ASTM A185 or A497 and ACI 318, using ASTM A82 wire of 75 ksi minimum tensile strength.
  - 2. Furnish flat sheets only, rolled sheets not permitted.

- E. Accessories
  - 1. Tie Wire
    - a. Black, soft-annealed 16-gauge wire.
    - b. Nylon, epoxy, or plastic-coated wire.
  - 2. Bar Supports and Spacers
    - a. Precast concrete bar supports, cementitious fiber-reinforced bar supports, or all-plastic bar supports and side form spacers meeting requirements of CRSI Manual of Standard Practice. Do not use other types of supports or spacers.
    - b. In Beams, Columns, Walls, and Slabs Exposed to View After Form Removal: Small rectangular concrete blocks made up of same color and strength as concrete being placed around them or all-plastic bar supports and side form spacers.
    - c. Precast concrete supports of same strength as concrete for reinforcing in concrete placed on grade.
    - d. Plastic Bar Supports: As manufactured by Aztec Concrete Accessories, Bloomington, CA.

### **2.03 FABRICATION**

- A. Follow CRSI Manual of Standard Practice.
- B. Bend bars cold.

## **PART 3 – EXECUTION**

### **3.01 PREPARATION**

- A. Notify OWNER'S REPRESENTATIVE when reinforcing is ready for inspection and allow sufficient time for inspection prior to placing concrete.
- B. Clean reinforcing bars of loose mill scale, oil, earth, and other contaminants.
- C. Coat wire projecting from precast concrete bar supports with dielectric material, epoxy, or plastic.

**3.02 INSTALLATION**

- A. Bundle or space reinforcing steel bars, instead of field bending where construction access through reinforcing is necessary.
- B. Spacing and Positioning: Conform to ACI 318.
- C. Location Tolerances: In accordance with CRSI publication, "Placing Reinforcing Bars".
- D. Splicing
  - 1. Follow ACI 318.
  - 2. Use lap splices, unless otherwise shown or permitted in writing by OWNER'S REPRESENTATIVE.
  - 3. Welded Splices: Accomplish by full penetration groove welds and develop a minimum of 125 percent of yield strength of bar.
  - 4. Stagger splices in adjacent bars where indicated.
- E. Mechanical Splices and Connections
  - 1. Use only where shown on the Drawings or in locations specifically approved in writing by OWNER'S REPRESENTATIVE.
  - 2. Install as required in Section 03212, REINFORCING BAR COUPLERS.
  - 3. Maintain minimum edge distance and concrete cover.
- F. Tying Reinforcing Bars
  - 1. Tie every other intersection on mats made up of Nos. 3, 4, 5, and 6 bars to hold them firmly at required spacing.
  - 2. Bend tie wire away from concrete surface to maintain minimum clearance of 1 inch from the surface of concrete to tie wire.
- G. Reinforcement Around Openings: Unless otherwise specified on drawings, on each side and above and below pipe or opening, place an equivalent area of steel bars to replace steel bars cut for opening. Extend steel reinforcing a standard lap length beyond opening at each end.
- H. Welding Reinforcement
  - 1. Weld reinforcing steel only when specifically approved in writing by the OWNER'S REPRESENTATIVE.
  - 2. Only A706 bars may be welded.

3. Do not perform welding until welder qualifications are approved.
  4. Provide suitable ventilation when welding epoxy-coated reinforcing bars.
- I. Straightening and Rebending: Field bending of reinforcing steel bars is not permitted.
- J. Unless permitted by OWNER'S REPRESENTATIVE, do not cut reinforcing bars in field.
- K. Welded Wire Fabric
1. Use only where specifically shown.
  2. Extend fabric to within 2 inches of edges of slab, and lap splices at least 1-1/2 wire spacing or minimum 12 inches.
  3. Tie laps and splices securely at ends and at least every 24 inches with tie wire.
  4. Place welded wire fabric on concrete blocks and rigidly support equal to that provided for reinforced bars. Do not use broken concrete, brick, or stone.
  5. Follow ACI 318 and current Manual of Standard Practice, Welded Wire Fabric.
  6. Do not use fabric that has been rolled. Install flat sheets only.

**3.03 TESTS AND INSPECTION**

- A. Retain an independent testing firm, approved by the OWNER'S REPRESENTATIVE, to visually inspect and test reinforcing steel welds in accordance with AWS D1.4.
- B. Retain an independent testing firm, approved by OWNER'S REPRESENTATIVE, to inspect each mechanical splice and verify each component is installed in accordance with manufacturer's instructions and Section 03212, REINFORCING BAR COUPLERS.
- C. Special inspection will be provided by the OWNER'S REPRESENTATIVE as indicated on the Drawings.

**END OF SECTION**

**PART 1 – GENERAL****1.01 DESCRIPTION**

- A. The WORK specified in this section includes the requirements for furnishing and installing reinforcing bar couplers as designated in the Contract.

**1.02 DEFINITIONS**

- A. References
1. American Society of Testing and Materials (ASTM)
    - a. A615 – Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
    - b. A706 – Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
  2. American Concrete Institute (ACI)
    - a. 318 – Building Code Requirements for Structural Concrete
  3. International Congress of Building Officials (ICBO)
  4. International Building Code (IBC) - 2003 Edition

**1.03 SUBMITTALS**

- A. Comply with the requirements of Section 01300, SUBMITTAL PROCEDURES.
- B. Submit the following information for each shipment of splice material:
1. The type or series identification of the splice material. For sleeve-threaded type, the heat treatment lot number.
  2. The bar grade and size number to be spliced by the material.
  3. A copy of the manufacturer's catalog giving complete data on the splice material and procedures.
  4. A statement that the splicing systems and materials used in accordance with the manufacturer's procedures will develop the strength requirements, the total slip requirements, and other requirements in these specifications.

**1.04 SYSTEM DESCRIPTION****A. Performance Requirements**

1. Do not exceed the following total slip of the reinforcing bars within the splice sleeve after loading reinforcing bar in tension to 30,000 pounds per square inch and relaxing to 3,000 pounds per square inch, measured between gauge points clear of the splice sleeve:
  - a. 0.010 inch for Number 14 reinforcing bars or smaller.
  - b. 0.030 inch for Number 18 reinforcing bars.
2. The splicing system and materials used in accordance with the manufacturer's procedures shall develop in tension not less than:
  - a. 125 percent of the specified yield strength of the reinforcing bar for ASTM A615 and ASTM A706 reinforcing bars.

**PART 2 – PRODUCTS****2.01 EQUIPMENT (NOT USED)****2.02 MATERIALS**

- A. Reinforcing Bar Couplers: Mechanical butt splices of the sleeve-threaded type or the sleeve-swaged type. Provide mechanical couplers that are tension-compression splice devices conforming to the requirements of ACI 318 and coupling devices accepted by the ICBO which meet the requirements of IBC.
  1. Sleeve-threaded Type of Reinforcing Bar Coupler
    - a. Steel splice sleeve with tapered interior threads that joins the reinforcing bars with matching tapered threads.
    - b. Taper threads to such a degree that cross threading will not occur during assembly.
    - c. Mark each splice sleeve with the heat treatment lot number.
    - d. After completion of assembly of the splice, tighten splice to a torque value of not less than 200 foot-pounds for all bar sizes.
  2. Sleeve-swaged type of reinforcing bar coupler: Seamless steel sleeve applied over the ends of the reinforcing bars and swaged to the bars by means of a hydraulic press.

3. Do not use mechanical coupler types which require installation in the dry or require special ventilation for underground construction.

**PART 3 – EXECUTION**

**3.01 CONSTRUCTION (NOT USED)**

**3.02 INSTALLATION**

- A. Use reinforcing bar couplers where indicated on the Drawings or accepted by the OWNER'S REPRESENTATIVE.
- B. Splice in accordance with the manufacturer's recommendations, except as modified in this section. Make splices using manufacturer's standard equipment, jigs, clamps, and other required accessories.
- C. Cut ends of reinforcing bars to be spliced nominally square.
- D. Provide clear cover over reinforcing bar couplers of not less than indicated on the Drawings or specified for the bars when measured from the surface of the concrete to the outside of the sleeve. Adjust stirrups, ties, and other reinforcement and place additional reinforcement if necessary to provide planned clear cover over reinforcement.

**END OF SECTION**

**PART 1 – GENERAL****1.01 DESCRIPTION**

- A. The WORK specified in this section includes the requirements for construction of joints in concrete and for furnishing and installing water stops, joint fillers, and expansion joint dowels as designated in the Contract.

**1.02 DEFINITIONS**

- A. References
1. American Society for Testing and Materials (ASTM)
    - a. C920 – Standard Specification for Elastomeric Joint Sealants
    - b. D226 – Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
    - c. D227 – Standard Specification for Coal-Tar-Saturated Organic Felt Used in Roofing and Waterproofing
    - d. D994 – Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
    - e. D1056 – Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
    - f. D1751 – Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
  2. Corps of Engineers (COE)
    - a. CRD-C-572 – Specifications for Polyvinylchloride Water stop

**1.03 SUBMITTALS**

- A. Comply with the requirements of Section 01300, SUBMITTAL PROCEDURES.
- B. Shop Drawings
1. Water Stops: Details of splices, method of securing and supporting water stop in forms to maintain proper orientation and location during concrete placement.

2. Construction and Control Joints: Layout and location for each type.
  - a. Detail showing reinforcing couplers, shear keys, and type and location of water stops. Specify method to be used to roughen surface.
  - b. Hydrophilic water stop.
- C. Samples: PVC water stop splice, joint, and fabricated cross of each size, shape, and fitting of water stop(s).
- D. Quality Control Submittals
  1. Manufacturer's written instructions for product shipment, storage, handling, installation/application, and repair for:
    - a. Water stop.
    - b. Joint filler and primer.

**1.04 QUALITY ASSURANCE**

- A. Qualifications: Evidence that water stop manufacturer has five years, minimum, continuous successful experience in production of PVC water stops.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Acceptance at Site: Verify that delivered materials are in accordance with Specifications and manufacturer's product data sheets prior to unloading and storing onsite.
- B. Storage: Store materials per manufacturer's recommendations.

**PART 2 – PRODUCTS****2.01 EQUIPMENT (NOT USED)****2.02 MATERIALS**

- A. Plastic Water Stop
  1. Extruded from elastomeric plastic compound of which basic resin shall be prime virgin polyvinyl chloride (PVC). Compound is not to contain scrapped material, reclaimed material, or pigment.
  2. Specific Gravity: Approximately 1.37.
  3. Shore Durometer Type A Hardness: Approximately 80.
  4. Performance Requirements: Corps of Engineers Specification CRD-C-572.

5. Type: Center bulb with parallel ribs or protrusions on each side of strip center.
  6. Corrugated or tapered type water stops are not acceptable.
  7. Thickness: Constant from bulb edge to outside stop edge.
  8. Minimum Weight per Foot of Water Stop
    - a. 1.60 pounds for 3/8 inch by six inch.
    - b. 2.30 pounds for 3/8 inch by nine inch.
  9. Factory Fabrications: Use only factory fabrications for intersections, transitions, and changes of direction.
  10. Manufacturers and Products
    - a. Vinylex Corp., Knoxville, TN; Catalog No. 03250/VIN: No. RB6-38H (six inches by 3/8 inch) and No. RB9-38H (nine inch by 3/8 inch)
    - b. Greenstreak Plastic Products, St. Louis, MO; Catalog No. 03150/GRD: Style 732 (six inches by 3/8 inch) and Style 735 (nine inch by 3/8 inch)
    - c. A. C. Horn, Inc., Beltsville, MD; Catalog No. CSP-162: Type 9 (six inches by 3/8 inch), and Type 10 (3/8 inch by nine inches)
    - d. Or approved equal
- B. Wire Looped Plastic Water Stop
1. Furnish as alternative to plastic water stops.
  2. Same material and geometry as plastic water stops.
  3. Furnish with continuous galvanized wire looping at edge, for convenience in positioning and securing stop in place in forms.
  4. Manufacturer and Product: Paul Murphy Plastics, Roseville, MI; "Wire Stop Water Stop"; geometry numbers ACR 6380, ACR 9380, as shown on Paul Murphy Plastics Co. Drawing No. CCP-120-12M, or approved equal.
- C. Hydrophilic Water Stop
1. For use at construction joints only where new concrete is placed against existing concrete and as shown on Drawings.
  2. Material is to be a nonbentonite hydrophilic rubber compound.

3. Manufacturers and Products
  - a. Greenstreak Plastic Products, St. Louis, MO; Hydrotite CJ-1020-2K with Leakmaster LV-1 adhesive and sealant
  - b. Adeka Ultra Seal, JLM Associates, Spearfish, SD; MC-2010M with 3M-2141 adhesive and P-201 sealant
  - c. Or approved equal
- D. Premolded Joint Filler
  1. Bituminous Type: ASTM D994 or D1751.
  2. Sponge Rubber
    - a. Neoprene, closed-cell, expanded; ASTM D1056, Type 2C5, with compression deflection, 25 percent deflection (limits), 119 to 168 kPa (17 to 24 psi) minimum. Use in joints for potable and nonpotable water containment structures.
    - b. Manufacturer and Product: Rubatex Corp.; R451N, or approved equal.
- E. Pourable Joint Fillers
  1. Filler for Nonpotable Water Containment Structures
    - a. Pourable, two-component, cold-applied compound meeting ASTM C920, Type M, Grade P, Class 25, Use T.
    - b. Color: Black.
    - c. Manufacturer and Product: W.R. Meadows, Inc., Elgin, IL; Gardox, or approved equal.
- F. Accessories
  1. Roofing Felt: ASTM D226, Type II, 30 pound asphalt-saturated or equal weight of ASTM D227 coal-tar saturated felt.
  2. Nails: Galvanized, as required for securing premolded joint filler.
  3. Masking Tape: As required to temporarily adhere to concrete at each side of joint to receive filler.
  4. Ties for PVC Water Stop: "Hog Rings" or grommets for each edge at 12 Constructware® inch maximum spacing.

**PART 3 – EXECUTION****3.01 CONSTRUCTION****A. General**

1. Commence concrete placement after joint preparation is complete.
2. Time Between Concrete Pours: As specified in Section 03300, CAST-IN-PLACE CONCRETE.
3. Maximum size of concrete pours: As specified in 03300, CAST-IN-PLACE CONCRETE.

**B. Preparation**

1. Construction Joints: Prior to placement of abutting concrete, clean contact surface:
  - a. Remove laitance and spillage from reinforcing steel and dowels.
  - b. Roughen surface to minimum of 1/4 inch amplitude by any of the following methods:
    - 1). Sandblast after concrete has fully cured.
    - 2). Water blast after concrete has partially cured.
    - 3). Green cut fresh concrete with high pressure water and hand tools.
  - c. Perform cleaning so as not to damage water stop, if one is present.
2. Construction Joint with Hydrophilic Water Stop
  - a. Follow hydrophilic water stop manufacturer's written instructions.
  - b. Except in cases where installation is performed under water, clean debris, dirt, dust, and foreign material from concrete surface. Concrete surface must be smooth, clean, and dry. Grind concrete as required.

**3.02 INSTALLATION****A. General**

1. Join water stops at intersections to provide continuous seal. Water stops are to be continuous through all construction joints.
2. Center water stop on joint.

3. Secure water stop in correct position. Tie water stop to reinforcing steel using grommets, "Hog Rings," or tie wire at maximum spacing of 12 inches. Do not displace water stop during concrete placement.
  4. Repair or replace damaged water stop.
  5. Place concrete and vibrate to obtain impervious concrete in vicinity of joints.
  6. Joints in Footings and Slabs
    - a. Ensure that space beneath plastic water stop is completely filled with concrete.
    - b. During concrete placement, make visual inspection of water stop area.
    - c. Limit concrete placement to elevation of water stop in first pass, vibrate concrete under water stop, lift water stop to confirm full consolidation without voids, then place remaining concrete to full height of slab and vibrate.
- B. Plastic Water Stop
1. Install in accordance with manufacturer's written instructions.
  2. Splice in accordance with water stop manufacturer's written instructions using Teflon coated thermostatically controlled heating iron at approximately 380 degrees F.
    - a. Allow at least ten minutes before new splice is pulled or strained in any way.
    - b. Provide finished splices with a cross-section that is dense and free of porosity with tensile strength of not less than 80 percent of unspliced materials.
    - c. Use only factory made water stop fabrications for all intersections, changes of directions and transitions.
    - d. Field splice permitted only for straight butt welds.
  3. Wire looped plastic water stop may be substituted for plastic water stop.
- C. Hydrophilic Water Stop
1. Install in accordance with manufacturer's written instructions.
  2. Provide minimum of 2-1/2 inches of concrete cover over water stop. When structure has two layers of reinforcing steel, locate centered between layers of steel or as shown.

3. Except in cases where installation is performed under water, apply adhesive to concrete surface and allow to dry for specified time before applying water stop strip.
4. Butt ends of water stop strip together at splices and corners and join with sealant.
5. Verify that water stop is anchored firmly in place before placing concrete. Do not allow vibrator to come into contact with water stop.

**D. Expansion Joint Installation**

**1. Pourable Joint Filler**

- a. General: Install in accordance with the manufacturer's written instructions, except as specified below:
  - 1) Apply primer prior to pouring joint filler.
  - 2) Fill entire joint above the water stop with joint filler as shown.
  - 3) Use masking tape on top of slabs at sides of joints; clean spillage. Remove masking tape afterwards.

**END OF SECTION**

**PART 1 – GENERAL****1.01 DESCRIPTION**

- A. The WORK specified in this Section includes the requirements for concrete components including cement, aggregate, admixtures, concrete mix design, quality control, and concrete placement as designated in the Contract.

**1.02 DEFINITIONS****A. General**

1. Exposed Concrete: Concrete surfaces that can be seen inside or outside of structures regardless whether concrete is above water, dry at all times, or can be seen when structure is drained.
2. Hydraulic Structures: Liquid containment basins or conveyance structures.
3. Defective Areas: Surface defects that include honeycomb, rock pockets, indentations greater than 3/16 inch, cracks 0.005-inch wide and larger as well as any crack that leaks for liquid containment basins and below grade habitable spaces; cracks 0.010-inch wide and larger in non-fluid holding structures, spalls, chips, air bubbles greater than 3/4 inch in diameter, pinholes, bug holes, embedded debris, lift lines, sand lines, bleed lines, leakage from form joints, fins and other projections, form pop outs, texture irregularities, and stains and other color variations that cannot be removed by cleaning.
4. New Concrete: Less than 60 days old.
5. Slurry Concrete: Mixture of sand, 3/8 inch minus aggregate, cement, and water for wall construction joints.

**B. References**

1. American Concrete Institute (ACI)
  - a. 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
  - b. 301 - Standard Specification for Structural Concrete
  - c. 302.1R - Guide For Concrete Floor and Slab Construction
  - d. 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete
  - e. 305R - Hot Weather Concreting
  - f. 306.1 - Standard Specification for Cold Weather Concreting

- g. 309R - Guide for Consolidation of Concrete
  - h. 318 - Building Code Requirements for Structural Concrete
  - i. 350 - Code Requirements for Environmental Engineering Concrete Structures
2. American Society for Testing and Materials (ASTM)
- a. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field
  - b. C33 - Standard Specification for Concrete Aggregates
  - c. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
  - d. C88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
  - e. C94 - Standard Specification for Ready-Mixed Concrete
  - f. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete
  - g. C150 - Standard Specification for Portland Cement
  - h. C157 - Standard Test Method for Length Change of Hardened Hydraulic - Cement Mortar and Concrete
  - i. C192 - Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
  - j. C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
  - k. C260 - Standard Specification for Air-Entraining Admixtures for Concrete
  - l. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete
  - m. C494 - Standard Specification for Chemical Admixtures for Concrete
  - n. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
  - o. C1012 - Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution

- p. C1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete
- q. D512 - Standard Test Method for Chloride Ion in Water
- r. D516 - Standard Test Method for Sulfate Ion in Water
- s. C989 - Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

### 1.03 SUBMITTALS

- A. Comply with the requirements of Section 01300, SUBMITTAL PROCEDURES, and additional requirements in this Section.
- B. Administrative Submittals: Pre-installation Conference minutes.
- C. Shop Drawings
  - 1. Product Data: Admixtures, bonding agent, bond breaker, and patching materials.
  - 2. Design Data: Concrete mix designs shall be certified by the mix designer, sealed and signed by an Oregon Professional Engineer, and approved by the OWNER'S REPRESENTATIVE.
  - 3. Placement Drawings
    - a. Concrete, identifying location of each type of construction joint.
    - b. Tremie concrete.
  - 4. Detailed plan for cold weather curing and protection of concrete placed and cured in weather below 40 degrees F.
  - 5. Detailed plan for hot weather placements including curing and protection for concrete placed in ambient temperatures over 80 degrees F.
  - 6. Concrete repair methods and materials.
- D. Quality Control Submittals
  - 1. Manufacturer's application instructions for bonding agent and bond breaker.
  - 2. Manufacturers' Certificate of Compliance
    - a. Portland cement.
    - b. Admixtures.

- c. Fly ash.
  - d. Silica Fume.
  - e. Aggregates.
  - f. Bonding agent.
  - g. Bond breaker.
  - h. Patching and repair materials.
  - i. Admixtures: Manufacturers' Certificate of Proper Installation.
  - j. Ground Granulated Blast-Furnace Slag
3. Statements of Qualification
- a. Concrete mix designer.
  - b. Batch plant.
4. Test Reports
- a. Admixtures, test reports showing chemical ingredients and percentage of chloride in each admixture and fly ash.
  - b. Source test analysis report for cements, fly ash, silica fume and ground granulated blast-furnace slag including percentage of chloride content.
  - c. Statement identifying aggregates reactivity. Determine water soluble chloride in each component of aggregates in accordance with ASTM C1218.
  - d. For each trial concrete mix design and signed by the approved concrete mix designer.
  - e. Cylinder compressive test results for laboratory concrete mixes.
  - f. Drying shrinkage test data as determined in accordance with ASTM C157.
  - g. Gradation for coarse and fine aggregates and combined together. List gradings percent passing through each sieve size.
5. Concrete Delivery Tickets
- a. For each batch of concrete before unloading at site.

- b. Record of drum revolution counter, type, brand, test certification, Amount of fly ash if used in accordance with ASTM C94, Section 16.

**1.04 QUALITY ASSURANCE**

A. Qualifications

- 1. Concrete Mix Designer: Licensed professional engineer registered in the State of Oregon.
- 2. Batch Plant: Currently certified by the National Ready Mixed Concrete Association.

B. Pre-installation Conference - to be held before each new type of work

1. Required Meeting Attendees

- a. CONTRACTOR, including pumping, placing and finishing, and curing subcontractors.
- b. Ready-mix producer.
- c. Admixture representative.
- d. Testing and sampling personnel.
- e. OWNER'S REPRESENTATIVE.

- 2. Schedule and conduct prior to incorporation of respective products into Project. Notify OWNER'S REPRESENTATIVE of location and time.

3. Agenda is to include:

- a. Admixture types, dosage, performance, and redosing at site.
- b. Mix designs, test of mixes, and Submittals.
- c. Placement methods, techniques, equipment, consolidation, and form pressures.
- d. Slump and placement time to maintain slump.
- e. Finish, curing, and water retention.
- f. Protection procedures for weather conditions.
- g. Other specified requirements requiring coordination.

- 4. Conference minutes.

- C. Prior to each concrete pour provide a completed pre-pour checklist to the OWNER'S REPRESENTATIVE. Format of checklist to be approved by OWNER'S REPRESENTATIVE.

## PART 2 – PRODUCTS

### 2.01 EQUIPMENT (NOT USED)

### 2.02 MATERIALS

#### A. Cement

1. Portland Cement Type II or Type V (ASTM C150)
  - a. Comply with the requirements for low alkali cement in ASTM C150 Table 2.
  - b. Use only one brand of each cementitious material.
  - c. Combine fly ash or ground granulated blast-furnace slag with cement at batch plant.
2. Cement used shall correspond to that on which selection of concrete proportion was based. If more than one source is used, supply cement of the same type and perform strength tests for each cement source.

#### B. Aggregates: Furnish from one source.

1. Natural Aggregates
  - a. Free from deleterious coatings and substances in accordance with ASTM C33, except as modified herein.
  - b. Free of materials and aggregate types causing pop outs, discoloration, staining, or other defects on surface of concrete.
2. Non-potentially Reactive: In accordance with ASTM C33, Appendix XI, paragraph X1.1.
3. Aggregate Soundness: Test for fine and coarse aggregates in accordance with ASTM C33 and ASTM C88 using sodium sulfate solution.
4. Fine Aggregates
  - a. Clean, sharp, natural sand.
  - b. ASTM C33.
  - c. Materials Passing 200 Sieve: 4 percent maximum.

- d. Limit deleterious substances in accordance with ASTM C33, Table 1 with material finer than 200 sieve limited to 3 percent, coal and lignite limited to 0.5 percent.
5. Coarse Aggregate
    - a. Natural gravels, combination of gravels and crushed gravels, crushed stone, or combination of these materials containing no more than 15 percent flat or elongated particles (long dimension more than five times the short dimension).
    - b. Materials Passing 200 Sieve: 0.5 percent maximum.
    - c. Limit deleterious substances in accordance with ASTM C33, Table 3 for exposed concrete.
- C. Admixtures: Furnish from one manufacturer.
1. Characteristics: Compatible with each other and free of chlorides or other corrosive chemicals.
  2. Air-Entraining Admixture
    - a. ASTM C260, nontoxic after 30 days and contains no chlorides.
    - b. Concrete with air-entrainment admixture added is to maintain air percentage as batched, within plus or minus two percent for time required for placement into structure.
  3. Water-Reducing Admixture: ASTM C494, Type A or Type D.
    - a. Manufacturers and Products
      - 1) Master Builders, Inc., Cleveland, OH; Pozzolith or Polyheed.
      - 2) W. R. Grace & Co., Cambridge, MA; WRDA with HYCOL.
      - 3) Euclid Chemical Co., Cleveland, OH; Eucon WR-91.
      - 4) Or approved equal.
  4. High Range Water Reducing Admixture (Superplasticizer): ASTM C494, Type F or Type G.
    - a. Hold slump of five inches or greater for time required for placement.
    - b. Furnish type as recommended by manufacturer for allowed temperature ranges.
    - c. Manufacturers and Products. Use one of the following or equal:

- 1) Master Builders, Inc., Cleveland, OH; Rheobuild or Polyheed at dosage greater than 10 ounces per 100 pounds of cement.
  - 2) W. R. Grace & Co., Cambridge, MA; Daracem 100.
  - 3) Euclid Chemical Co., Cleveland, OH; Eucon 537.
  - 4) Or approved equal.
5. Pozzolan (Fly Ash): Class F fly ash in accordance with ASTM C618, Table 1 and 2, except as modified herein:
- a. Not be produced from process that has utilized hazardous or potentially hazardous materials.
  - b. Loss on Ignition: Maximum three percent.
  - c. Water Requirement: Maximum 100 percent of control.
  - d.  $\frac{CaO(\%) - 5}{FE_2O_3(\%)}$ : *Maximum 1.5*
  - e. ASTM C618, Table 1A applies when aggregate or portion of coarse or fine aggregate used is reactive as specified in paragraph Non-potentially Reactive.
  - f. ASTM C618, Table 2A, Reactivity with Cement Alkalis, applies when aggregate or portions of aggregate is reactive as specified under paragraph Non-potentially Reactive.
  - g. ASTM C618, Table 2A, Uniformity Requirements, applies when loss on ignition of fly ash furnished exceeds three percent.
6. For fly ash not meeting requirements of chemical ratio listed above, furnish the following:
- a. Test fly ash in accordance with ASTM C1012.
  - b. Furnish test data confirming fly ash in combination with cement used meets strength requirements, is compatible with air-entraining agents and other additives, and provides increased sulfate resistance equivalent to or better than Type II cement.
  - c. Conduct tests using proposed fly ash and cement samples together with control samples using Type II cement without fly ash.

7. Silica Fume: ASTM C1240
  8. Ground Granulated Blast-Furnace Slag: In accordance with ASTM C989 Grade 100 or as approved by the OWNER'S REPRESENTATIVE. Alumina content less than 11 percent.
- D. Water: Clean and potable containing less than 500 ppm of chlorides as determined by ASTM D512, and less than 500 ppm of sulfates, as determined by ASTM D516.
- E. Slurry Concrete For Horizontal Construction Joints In Walls
1. Flowable, consisting of sand, 3/8-inch minus aggregate, water, and minimum 1,128 pounds of cement per cubic yard.
- F. Ancillary Materials
1. Bonding Agent
    - a. Furnish as recommended by manufacturer for surface finish, pot life, set time, vertical or horizontal application and forming restrictions.
    - b. Manufacturers:
      - 1) Master Builders Technologies, Cleveland OH
      - 2) Sika Chemical Corp., Lyndhurst NJ
      - 3) Euclid Chemical Co., Cleveland, OH
      - 4) Or approved equal.
  2. Bond Breaker
    - a. Non-staining type, providing positive bond prevention.
    - b. Manufacturers and Products
      - 1) Williams Distributors, Inc., Seattle, WA; Williams Tilt-Up Compound.
      - 2) SCA Construction Supply Div., Superior Concrete Accessories, Franklin Park, IL; Silcoseal 77.
      - 3) Burke Co., San Mateo, CA; Burke Clean Lift Bond Breaker or Burke Tilt Free Bond Breaker.
      - 4) Or approved equal.

3. Repair Material
  - a. Contain no chlorides or other chemicals causing steel corrosion.
  - b. Repair mortar specifically mixed and then tested at jobsite for appearance compatibility prior to use in exposed areas.
  - c. Low pressure spray or hand applied silica fume mortar, for vertical and overhead repair, as specified in Section 03700, CONCRETE REPAIR.
  - d. Repair mortar system submitted and approved for horizontal concrete surface repairs from list of repair mortars in Section 03700, CONCRETE REPAIR.
4. Conduit Encasement Coloring Agent
  - a. Color: Red color concrete used for encasement of electrical ducts, conduits and similar type items.
  - b. Manufacturers: One of the following, or equal:
    - 1) Frank D. Davis Company, Red Oxide Number 1117.
    - 2) Reiss Company, Inc., equivalent product
  - c. Conduit Encasement Concrete: 10 pounds of coloring agent per cubic yard of concrete.

### 2.03 CONCRETE MIX DESIGN

- A. Design: Select and proportion ingredients using trial batches; sample, cure and test concrete mix through approved independent testing laboratory in accordance with ACI 211.1.
  1. Concrete Compressive Strength  $f'_c$ .
    - a. See [Concrete Mix Table on Drawing S001](#).
    - b. Prepare adequate lab-cured trial mix cylinders for testing.
    - c. Use additional cementitious material above minimum specified if required to meet average compressive strength,  $f'_{cr}$ .
    - d. Use  $f'_{cr}$  as basis for selection of concrete proportions as set forth in ACI 301.
    - e.  $f'_{cr}$ : Equal to  $f'_c$  plus 1,200 when data is not available to establish standard deviation.

## B. Proportions

1. [See Concrete Mix Table on Drawing S001.](#)
2. In accordance with ACI 211.1, unless specified otherwise.
3. Minimum Cementitious Content ([Cement](#) or Combined Cement Plus Fly Ash or Combined Cement Plus Ground Granulated Blast-Furnace Slag Content) [shall be as specified in Concrete Mix Table on Drawing S001.](#)
  - a. Increase cement content or combined cement plus fly ash content, or combined cement plus ground granulated blast-furnace slag as required to meet strength requirements and water-cement ratio.
4. Ground Granulated Blast-Furnace Slag: Shall be 60 percent of total weight of ground granulated blast-furnace slag plus cement.

## C. Aggregate Shrinkage Effects: Design mix for shrinkage characteristics of aggregate. Test for shrinkage in accordance with ASTM C157, results at 28 days shall not exceed 0.048 percent. Aggregate will be rejected if test values exceed these limits.

## D. Admixtures

1. Air Content: [±1% of required per Concrete Mix Table on Drawing S001](#) when tested in accordance with ASTM C231.
2. Fly Ash: Maximum 25 percent, minimum 15 percent of total weight of fly ash plus cement.
3. Water Reducers: Use in all concrete.
4. High Range Water Reducers (Superplasticizers): Use in wall concrete equal to or less than 24 inches thick. Use in confined or heavily reinforced areas and under 48-inch diameter and larger pipes penetrating walls. May be used elsewhere if approved by the OWNER'S REPRESENTATIVE. Control slump and workability to at least 4 1/2-inch slump at discharge into forms by adjusting high range water reducer at batch plant.

## E. Slump Range at Site

1. 4 1/2 inches minimum, eight inches maximum for concrete with a high range water reducing admixture.
2. Three inches minimum and five inches maximum for concrete without high range water reducing admixture.

## F. Combined Aggregate Gradation

1. Structures: Select one of the gradations shown in the following table.
2. Combined Gradation Limits: Limits shown are for coarse aggregates and fine aggregates mixed together (combined).

Sieve Sizes	Combined Gradation		
	Percentage Passing		
	1-1/2" Max.	1" Max.	3/4" Max.
2"	- 100	-	-
1-1/2"	95 – 100	- 100	-
1"	65 - 85	90 - 100	- 100
3/4"	55 - 75	70 - 90	92 – 100
1/2"	-		68 – 86
3/8"	40 – 55	45 - 65	57 – 74
No. 4	30 – 45	31 - 47	38 – 57
No. 8	23 – 38	23 - 40	28 – 46
No. 16	16 – 30	17 - 35	20 – 36
No. 30	10 – 20	10 - 23	14 – 25
No. 50	4 – 10	2 - 10	5 – 14
No. 100	0 – 3	0 - 3	0 – 5
No. 200	0 – 2	0 - 2	0 – 2

## G. Tremie Concrete, including slurry wall and bottom (tremie) slab

1. Minimum cement content of 658 pounds per cubic yard.
2. Use high range water reducing admixture (superplasticizers) in accordance with ASTM C494, Type F or Type G.
3. Fine Aggregate Range: 40 to 50 percent of total aggregates by weight.
4. Use natural round gravel if available in Project area.
5. Proportion mix for design strength and slump range of 6 to 12 inches with maximum water-cement ratio 0.40.

**2.04 CONCRETE MIXING**

- A. General: In accordance with ACI 304R.
- B. Concrete Mix Temperatures: As shown below for various stages of mixing and placing:

<b>CONCRETE TEMPERATURES</b>				
<b>Ambient Air Temp.</b>	<b>Concrete Member Size, Minimum Dimension</b>			
	<b>&lt;12"</b>	<b>12"-36"</b>	<b>36"-72"</b>	<b>&gt;72"</b>
Minimum concrete temperature as mixed for indicated air temperature:				
Above 30 deg. F	60 deg. F	55 deg. F	50 deg. F	45 deg. F
0 to 30 deg. F	65 deg. F	60 deg. F	55 deg. F	50 deg. F
Below 0 deg. F	70 deg. F	65 deg. F	60 deg. F	55 deg. F
Maximum allowable gradual temperature drop in first 24 hours after curing period and after end of protection:				
–	50 deg. F	40 deg. F	30 deg. F	20 deg. F

- C. Truck Mixers
1. Equip with electrically actuated counters to readily verify number of revolutions of drum or blades.
  2. Counter
    - a. Resettable, recording type, mounted in driver's cab.
    - b. Actuated at time of starting mixers at mixing speeds.
  3. Truck mixer operation shall furnish concrete batch as discharged that is homogeneous with respect to consistency, mix, and grading.
  4. Meet the requirements of ASTM C94 for Slump tests taken at approximately the 15 percent and 85 percent points of the load during discharge
  5. Before attempting to reuse unit, check mechanical details of mixer, such as water measuring, and discharge apparatus, condition of blades, speed of rotation, general mechanical condition of unit, admixture dispensing equipment, and clearance of drum.
  6. Do not use non-agitating or combination truck and trailer equipment for transporting ready-mixed concrete.
  7. Concrete Volume in Truck

- a. Limit to 63 percent of total volume capacity in accordance with ASTM C94 when truck mixed.
  - b. Limit to 80 percent of total volume capacity when central mixed.
  8. Mix each batch of concrete in truck mixer for minimum 70 revolutions of drum or blades at rate of rotation designated by equipment manufacturer.
  9. Perform additional mixing, if required, at speed designated by equipment manufacturer as agitating speed.
  10. Place materials, including mixing water, in mixer drum before actuating revolution counter for determining number of mixing revolutions.
- D. Aggregates: Thoroughly and uniformly wash before use.
- E. Admixtures
1. Air-Entraining Admixture: Add at plant through manufacturer-approved dispensing equipment.
  2. Water Reducers: Add prior to addition of high range water reducing admixture (superplasticizers).
  3. High range water reducing admixture (superplasticizers) and Air-Entraining Admixtures
    - a. Add at concrete plant only through equipment furnished or approved by admixture manufacturer.
    - b. Accomplish variations in slump, working time, and air content for flowable mixes by increasing or reducing high range water reducing admixture (superplasticizers) dose or air-entraining admixture dose at ready-mix plant only.
    - c. Use equipment that provides easy and quick visual verification of admixture amount used for each dose.
    - d. Add discharge amount to each load of concrete into separate dispensing container, verify amount is correct, and add to concrete.
    - e. Additional dosage of high range water reducing admixture (superplasticizers) may be added in field using manufacturer-approved dispensing when unexpected delays cause too great of slump loss.

**2.05 SOURCE QUALITY CONTROL**

- A. Cement: Test for Material properties specified in paragraph 2.02.A.1.

- B. Fly Ash: Test in accordance with ASTM C311.
- C. Batch Plant Inspection: Provide access to the OWNER'S REPRESENTATIVE to inspect batch plants, cement mills, and supply facilities of suppliers, manufacturers, and Subcontractors, providing products included in these Specifications.
  - 1. Weighing Scales: Tested and certified within tolerances set forth in the National Bureau of Standards Handbook No. 44.
  - 2. Batch Plant Equipment: Either semiautomatic or fully automatic in accordance with ASTM C94.
- D. Ground Granulated Blast-Furnace Slag: Test in accordance with requirements of ASTM C989.

**PART 3 – EXECUTION****3.01 PLACING CONCRETE**

- A. Preparation: Meet requirements and recommendations of ACI 304R and ACI 301, except as modified herein.
- B. Inspection: Notify OWNER'S REPRESENTATIVE at least one full working day in advance before starting to place concrete.
- C. Discharge Time
  - 1. As determined by set time, do not exceed 1-1/2 hours after adding cement to water unless special approved time delay admixtures are used. Coordinate time delay admixture information with manufacturer and OWNER'S REPRESENTATIVE prior to placing concrete.
  - 2. Adjust slump or air content at site by adding admixtures for particular load when approved by OWNER'S REPRESENTATIVE. Then, adjust plant dosage for remainder of placement. Use approved dispenser supplied by admixture manufacturer for additional dosage at the site.
  - 3. Maintain required slump throughout time of concrete placement and consolidation. Discontinue use of high range water reducing admixture (superplasticizers) and provide new mix design if it fails to maintain slump between four to eight inches and produce good consolidation for the length of time required. Redesign mix adjusting set control admixtures to maintain setting time in range required.
- D. Placement into Formwork
  - 1. Before depositing concrete, remove debris from space to be occupied by concrete.

2. Prior to placement of concrete, dampen fill under slabs on ground, dampen sand where vapor retarder is specified, and dampen wood forms.
3. Reinforcement: Secure in position before placing concrete.
4. Place concrete as soon as possible after leaving mixer, without segregation or loss of ingredients, without splashing forms or steel above, and in layers not over 1.5 feet deep, except for slabs which shall be placed full depth. Place and consolidate successive layers prior to initial set of first layer to prevent cold joints.
5. Use placement devices, for example, chutes, pouring spouts, and pumps.
6. Vertical Free Fall Drop to Final Placement: 5 feet in forms 8 inch or less wide and 8 feet in forms wider than 8 inches, except as specified.
  - a. Superplasticized Mixes: Up to 15 feet if slump is over 6 inches.
  - b. For placements where drops are greater than specified, use placement device such that free fall below placement device conforms to required value.
  - c. Limit free fall to prevent segregation caused by aggregates hitting reinforcing steel.
7. Do not use aluminum conveying devices.
8. Provide sufficient illumination in the interior of forms so concrete deposition is visible, permitting confirmation of consolidation quality.
9. Joints in Footings and Slabs
  - a. Ensure space beneath plastic water stop completely fills with concrete.
  - b. During concrete placement, make visual inspection of entire water stop area.
  - c. Limit concrete placement to elevation of water stop in first pass, vibrate concrete under water stop, lift water stop to confirm full consolidation without voids, place remaining concrete to full height of slab and vibrate.
  - d. Apply procedure to full length of water stops.
10. If reinforcement is in direct sunlight or is more than 20 degrees F higher in temperature than concrete temperature before placement, wet reinforcement with water fog spray before placing concrete to cool reinforcement.
11. Trowel and round off top exposed edges of walls with 1/4-inch radius steel edging tool.

- E. Conveyor Belts and Chutes
1. Design and arrange ends of chutes, hopper gates, and other points of concrete discharge throughout conveying, hoisting, and placing system for concrete to pass without becoming segregated.
  2. Do not use chutes longer than 50 feet.
  3. Minimum Slopes of Chutes: Angled to allow concrete to readily flow without segregation.
  4. Conveyor Belts
    - a. Approved by OWNER'S REPRESENTATIVE.
    - b. Wipe clean with device that does not allow mortar to adhere to belt.
    - c. Cover conveyor belts and chutes.
- F. Retempering: Not permitted for concrete where cement has partially hydrated.
- G. Pumping of Concrete
1. Provide standby pump, conveyor system, crane and concrete bucket, or other system onsite during pumping, for adequate redundancy to assure completion of concrete placement without cold joints in case of primary placing equipment breakdown.
  2. Minimum Pump Hose (Conduit) Diameter: four inches.
  3. Replace pumping equipment and hoses (conduits) that are not functioning properly.
- H. Maximum Size of Concrete Placements
1. Limit size of each placement to allow for strength gain and volume change due to shrinkage
  2. Locate expansion, control, contraction, and construction joints where shown. When expansion or control joints are not shown, provide construction joints at maximum spacing of 60 feet. When expansion or control joint spacing exceeds 60 feet, provide intermediate construction joints at maximum spacing of 40 feet. Uniformly space construction joints. Vertical construction joint shall not be greater than 20 feet from wall corners or intersections
  3. Consider beams, girders, brackets, column capitals, and haunches as part of floor or roof system and place monolithically with floor or roof system.
  4. Should placement sequence result in cold joint located below finished water surface, install water stop in joint.

- I. Minimum Time Between Adjacent Placements
  - 1. Construction Joints: Do not place fresh concrete until previous pour has reached a minimum compressive strength of 2,000 psi.
  - 2. Control Joints: six days.
  - 3. Expansion Joints/Contraction Joints: one day.
  - 4. At least two hours shall elapse after depositing concrete in long columns and walls thicker than eight inches before depositing concrete in beams, girders, or slabs supported thereon.
  - 5. For columns and walls ten feet in height or less, wait at least 45 minutes prior to depositing concrete in beams, girders, brackets, column capitals, or slabs supported thereon.
  
- J. Removal of Water: Unless tremie method for placing concrete is specified, remove water from space to be occupied by concrete.
  
- K. Consolidation and Visual Observation
  - 1. Consolidate concrete with internal vibrators with minimum frequency of 8,000 cycles per minute and amplitude as required to consolidate concrete in section being placed.
  - 2. Provide at least one standby vibrator in operable condition at placement site prior to placing concrete.
  - 3. Consolidation Equipment and Methods: ACI 309R.
  - 4. Provide sufficient windows in forms or limit form height to allow for concrete placement through windows and for visual observation of concrete.
  - 5. Vibration consolidation shall not exceed distance of three feet from point of placement.
  - 6. Vibrate concrete in vicinity of joints to obtain impervious concrete.
  
- L. Hot Weather
  - 1. Prepare ingredients, mix, place, cure, and protect in accordance with ACI 305R.
  - 2. Placement frequency shall be such that lift lines will not be visible in exposed concrete finishes.

3. Maintain concrete temperature below 90 degrees F at time of placement, or furnish test data or provide other proof that admixtures and mix ingredients do not produce flash set plastic shrinkage, or cracking due to heat of hydration. Cool ingredients before mixing to maintain fresh concrete temperatures as specified or less.
4. Provide for windbreaks, shading, fog spraying, sprinkling, ice, wet cover, or other means as necessary to maintain concrete at or below specified temperature.
5. Prevent differential temperature between reinforcing steel and concrete.
6. Evaporation Retardant: As specified in Section 03370, CONCRETE CURING.

M. Cold Weather Placement

1. Do not place concrete when ambient temperature is below 40 degrees F or approaching 40 degrees F and falling, without special protection as specified or approved by OWNER'S REPRESENTATIVE.
2. Do not place concrete against frozen earth or ice, or against forms and reinforcement with frost or ice present.
3. Provide heated enclosures when air temperatures are below 40 degrees F.
4. Maintain surface temperature of concrete above 40 degrees F and cure concrete as specified in Section 03370, CONCRETE CURING, for minimum of 7 days.
5. Provide maximum and minimum thermometers placed on concrete surfaces spaced throughout WORK to allow monitoring of concrete surface temperatures representative of WORK.
6. In accordance with ACI 306.1 and ACI 301.
7. External Heating Units:
  - a. Vent heating units to atmosphere and do not locally heat or dry concrete. Where water cure is specified, maintain wet condition.
  - b. Do not exhaust heater flue gases, (causes concrete carbonation due to concentrated carbon dioxide,) directly into enclosed area.
8. Maintain curing conditions as specified in Section 03370, CONCRETE CURING.

**3.02 PLACING TREMIE CONCRETE**

- A. Place concrete when water level inside area to be filled with concrete is equal to groundwater elevation outside.
- B. Maintain relation of water levels until concrete design strength is obtained.

**3.03 CONCRETE BONDING**

- A. Horizontal Construction Joints in Reinforced Concrete Walls
  - 1. Thoroughly clean and saturate surface of joint with water.
  - 2. Limit slurry concrete placement to two inch maximum thickness, 1-inch minimum thickness.
  - 3. Use positive measuring device such as bucket or other device that will contain only enough slurry concrete for depositing in visually measurable area of wall to ensure that portion of form receives appropriate amount of slurry concrete to satisfy placement thickness requirements.
  - 4. Do not deposit slurry concrete from pump hoses or large concrete buckets, unless specified placement thickness can be maintained and verified through inspection windows close to joint.
  - 5. Limit concrete placed immediately on top of slurry concrete to 12 inches thick. Thoroughly vibrate to mix concrete and slurry concrete together.
- B. To Existing Concrete
  - 1. Thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 1/4 inch.
  - 2. Saturate surface with water for 24 hours prior to placing new concrete.

**3.04 CONSTRUCTION JOINTS**

- A. As specified in Section 03251, CONCRETE JOINTS.

**3.05 REPAIRING CONCRETE**

- A. General
  - 1. Inject cracks that leak with crack repair epoxy as specified in Section 03700, CONCRETE REPAIR.
  - 2. Repair horizontal concrete surfaces using one of the materials specified in Section 03700, CONCRETE REPAIR. Select system, submit for review, and obtain approval from OWNER'S REPRESENTATIVE prior to use.

3. Repair vertical and overhead concrete as specified in Section 03700, CONCRETE REPAIR.
  4. Obtain quantities of repair material and manufacturer's detailed instructions for use to provide repair with finish to match adjacent surface or apply sufficient repair material adjacent to repair to blend finish appearance.
  5. Repair concrete to provide structurally sound surface finish that is uniform in appearance or upgrade finish by other means until acceptable to OWNER'S REPRESENTATIVE.
- B. Tie Holes
1. Fill with non-shrink grout.
  2. Match color of adjacent concrete and demonstrate on test locations identified by the OWNER'S REPRESENTATIVE first.
  3. Compact grout using steel hammer and steel tool to drive grout to high density. Cure grout with water.
- C. Alternate Form Ties; Through-Bolts
1. Mechanically roughen entire interior surface of through hole. Epoxy coat roughened surface and drive elastic vinyl plug to half depth. Dry pack entire hole from both sides of plug with non-shrink grout in Section 03600, STRUCTURE GROUT. Use only enough water to dry pack grout. Dry pack while epoxy is still tacky. If epoxy has dried, remove epoxy by mechanical means and reapply new epoxy.
  2. Compact grout using steel hammer and steel tool to drive grout to high density. Cure grout with water.
- D. Exposed Metal Objects
1. Metal objects not intended to be exposed in as-built condition of structure including wire, nails, and bolts, shall be removed by chipping back concrete to depth of 1 inch and then cutting or removing metal object.
  2. Repair area of chipped-out concrete per requirements of Section 03700, CONCRETE REPAIR.
- E. Blockouts at Pipes or Other Penetrations
1. Install per details shown on Drawings or submit proposed blockouts for review.
  2. Use non-shrink, nonmetallic grout, Category I or II.

**3.06 CONCRETE WALL FINISHES**

- A. Type W-1 (Ordinary Wall Finish)
  - 1. Patch tie holes.
  - 2. Knock off projections.
  - 3. Patch defective areas.
  
- B. Type W-2 (Smooth Wall Finish)
  - 1. Patch tie holes.
  - 2. Grind off projections, fins, and rough spots.
  - 3. Patch defective areas and repair rough spots resulting from form release agent failure or other reasons to provide smooth uniform appearance.

**3.07 CONCRETE SLAB FINISHES**

- A. General
  - 1. Finish slab concrete per the requirements of ACI 302.1R.
  - 2. Use manual screeds, vibrating screeds, or roller compacting screeds to place concrete level and smooth.
  - 3. Do not use "jitterbugs" or other special tools designed for purpose of forcing coarse aggregate away from surface and allowing layer of mortar, which will be weak and cause surface cracks or delamination, to accumulate.
  - 4. Do not dust surfaces with dry materials.
  - 5. Use evaporation retardant.
  - 6. Round off edges of slabs with steel edging tool, except where cove finish is shown. Steel edging tool radius shall be 1/4 inch for slabs subject to wheeled traffic.
  
- B. Type S-1 (Steel Troweled Finish)
  - 1. Finish by screeding and floating with straightedges to bring surfaces to required finish elevation. Use evaporation retardant.
  - 2. While concrete is still green, but sufficiently hardened to bear a person's weight without deep imprint, wood float to true, even plane with no coarse aggregate visible.
  - 3. Use sufficient pressure on wood floats to bring moisture to surface.

4. After surface moisture has disappeared, hand trowel concrete to produce smooth, impervious surface, free from trowel marks.
  5. Burnish surface with an additional troweling. Final troweling shall produce ringing sound from trowel.
  6. Do not use dry cement or additional water during troweling, nor will excessive troweling be permitted.
  7. Power Finishing
    - a. Approved power machine may be used in lieu of hand finishing in accordance with directions of machine manufacturer.
    - b. Do not use power machine when concrete has not attained necessary set to allow finishing without introducing high and low spots in slab.
    - c. Do first steel troweling for slab S-1 finish by hand.
- C. Type S-2 (Wood Float Finish)
1. Finish slab to receive fill and mortar setting bed by screeding with straightedges to bring surface to required finish plane.
  2. Wood float finish to compact and seal surface.
  3. Remove laitance and leave surface clean.
  4. Coordinate with other finish procedures.
- D. Type S-3 (Underside Elevated Slab Finish): When forming is removed, grind off projections on underside of slab and patch defective areas, including small shallow air pockets where schedule of concrete finishes requires.
- E. Type S-4 (Broomed Finish)
1. Finish as specified for Type S-1 floor finish, except omit final troweling and finish surface by drawing coarse-hair broom lightly across surface.
  2. Broom in same direction and parallel to expansion joints, or, in the case of inclined slabs, perpendicular to slope, except for round roof slab, broom surface in radial direction.

- F. Type S-5 (Sidewalk Finish)
1. Slope walks down 1/4 inch per foot away from structures, unless otherwise shown.
  2. Strike off surface by means of strike board and float with wood or cork float to true plane, then flat steel trowel before brooming.
  3. Broom surface at right angles to direction of traffic or as shown.
  4. Lay out sidewalk surfaces in blocks, as shown or as directed by OWNER'S REPRESENTATIVE, with grooving tool.
- G. Concrete Curbs
1. Float top surface of curb smooth, and finish all discontinuous edges with steel edger.
  2. After concrete has taken its initial set, remove front form and give exposed vertical surface an ordinary wall finish, Type W-1.

### 3.08 CONCRETE SLAB TOLERANCES

- A. Slab Tolerances
1. Exposed Slab Surfaces: Comprise of flat planes as required within tolerances specified.
  2. Slab Finish Tolerances and Slope Tolerances: Crowns on floor surface not too high as to prevent 10-foot straightedge from resting on end blocks, nor low spots that allow block of twice the tolerance in thickness to pass under supported 10-foot straightedge.
  3. Slab Type S-A: Steel gauge end block 5/16 inch thick.
  4. Slab Type S-B: Steel gauge end block 1/8 inch thick.
  5. Slab Type S-A and S-B: Finish Slab Elevation: Slope slabs to floor drain and gutter, and shall adequately drain regardless of tolerances.
  6. Thickness: Maximum 1/4 inch minus or 1/2 inch plus from thickness shown. Where thickness tolerance will not affect slope, drainage, or slab elevation, thickness tolerance may exceed 1/2 inch plus.
- B. Thickness: Maximum 1/4 inch minus or 1/2 inch plus from thickness shown. Where thickness tolerance will not affect slope, drainage, or slab elevation, thickness tolerance may exceed 1/2 inch plus.

**3.09 BEAM AND COLUMN FINISHES**

- A. General: Inject cracks with crack repair epoxy as specified in Section 03700, CONCRETE REPAIR. Patch and repair defective areas.
- B. Type B-1: Match wall Type W-1.
- C. Type B-2: Match wall Type W-2.
- D. Type C-1: Match wall Type W-1.
- E. Type C-2: Match wall Type W-2.

**3.10 BACKFILL AGAINST WALLS**

- A. Do not backfill against walls until concrete has obtained specified 28 day compressive strength.
- B. Place backfill simultaneously on both sides of wall, where required, to prevent differential pressures.

**3.11 FIELD QUALITY CONTROL**

- A. General
  - 1. Provide adequate facilities for safe storage and proper curing of concrete test cylinders onsite for first 24 hours, and for additional time as may be required before transporting to test lab.
  - 2. Provide concrete for testing of slump, air content, and for making cylinders from the point of discharge into forms. When concrete is pumped, take samples used from discharge end of pump hose or truck chute when sampling from the pump discharge is impractical or unsafe.
  - 3. Evaluation will be in accordance with ACI 301 1.66 Evaluation of Concrete Strength Tests and 1.67 Acceptance of Concrete Strength, and Specifications.
  - 4. Specimens shall be made, cured, and tested by the CONTRACTOR in accordance with ASTM C31 and ASTM C39.
  - 5. Frequency of testing may be changed at discretion of OWNER'S REPRESENTATIVE.
  - 6. Pumped Concrete: Take concrete samples for slump (ASTM C143) and test cylinders (ASTM C31 and C39) at placement (discharge) end of line.
  - 7. Reject concrete represented by cylinders failing to meet strength and air content specified.

- B. High Range Water Reducer (Superplasticizer) Admixture Segregation Test: Test each truck prior to use on job.
1. Segregation Test Objective: Concrete with four to eight inch slump must stay together when slumped. Segregation is assumed to cause mortar to flow out of mix even though aggregate may stay piled enough to meet slump test.
  2. Test Procedure: Make slump test and check for excessive slump and observe to see if mortar or moisture flows from slumped concrete.
  3. Reject concrete if mortar or moisture separates and flows out of mix.
- C. Cold Weather Placement Tests
1. During cold weather concreting, cast cylinders for field curing as follows. Use method that will produce greater number of specimens:
    - a. Six extra test cylinders from last 100 cubic yards of concrete.
    - b. Minimum three specimens during each two hours of placing time or for each 100 cubic yards.
  2. These specimens shall be in addition to those cast for lab testing.
  3. Protect test cylinders from weather until they can be placed under same protection provided for concrete of structure that they represent.
  4. Keep field test cylinders in same protective environment as parts of structure they represent to determine if specified strength has been obtained.
  5. Test cylinders in accordance with applicable sections of ASTM C31 and C39.
  6. Use test results to determine specified strength gain prior to false work removal or for prestressing.
- D. Tolerances
1. Walls: Measure and inspect walls for compliance with tolerances specified in Section 03100, CONCRETE FORMWORK.
  2. Slab Finish Tolerances and Slope Tolerances
    - a. Floor flatness measurements shall be made one day after floor is finished and before shoring is removed to eliminate effects of shrinkage, curing, and deflection.
    - b. Support ten foot long straightedge at each end with steel gauge blocks of thicknesses equal to specified tolerance.

- c. Compliance with designated limits in four of five consecutive measurements is satisfactory, unless defective conditions are observed.

### 3.12 MANUFACTURER'S SERVICES

- A. Provide the following representative at site for installation assistance, inspection, and certification of proper installation for concrete ingredients, mix design, mixing, and placement.
  1. Batch Plant Representative
    - a. Observe how concrete mixes are performing.
    - b. Be present during first placement of each type of concrete mix.
    - c. Assist with concrete mix design, performance, placement, weather problems, and problems as may occur with concrete mix throughout Project.
    - d. Establish control limits on concrete mix designs.
  2. Admixture Manufacturer's Representative
    - a. Demonstrate special features, product performance, product mixing, testing, and placement or installation for each type of admixture.
    - b. Observe how concrete mixes are performing.
    - c. Be present during first placement of each type of concrete mix.
    - d. Assist with concrete mix design, performance, placement, weather problems, and problems as may occur with concrete mix throughout Project, including instructions for redosing.
    - e. Provide equipment for control of concrete redosing for air entrainment or high range water reducing admixture (superplasticizers) at site to maintain proper slump and air content if so needed.
  3. Bonding Agent Manufacturer's Representative: Demonstrate product performance, product mixing, and placement.

### 3.13 PROTECTION OF INSTALLED WORK

- A. After curing as specified in Section 03370, CONCRETE CURING, and after applying final floor finish, cover slabs with plywood or particle board or plastic sheeting or other material to keep floor clean and protect it from damage due to other construction work.
- B. Repair defective areas and areas damaged by construction.

**3.14 SCHEDULE OF CONCRETE FINISHES**

- A. Form Tolerances: As specified in Section 03100, CONCRETE FORMWORK.
- B. Provide concrete finishes as scheduled:

Area	Type of Finish	Required Form/Slab Tolerances
<b>EXTERIOR WALL SURFACES</b>		
Above grade/exposed (above a point 6" below finish grade)	W-2	W-B
Backfilled/waterproofed (below a point 6" below finish grade)	W-1	W-A
Backfilled/not waterproofed (below a point 6" below final grade)	W-1	W-A
<b>INTERIOR WALL SURFACES</b>		
Open top water-holding tanks and basins/not painted or coated	W-2	W-A
Covered water-holding tanks and basins/not painted or coated	W-1	W-A
Buildings, pipe galleries, and other dry areas/not painted or coated	W-2	W-A
<b>EXTERIOR SLABS</b>		
Roof slab/exposed	S-4	S-B
Water-holding tanks and basins/top of wall	S-1	S-B
Other water-holding tanks and basins	S-1	S-A
Sidewalks	S-5	S-B
Other exterior slabs	S-1	S-A
<b>INTERIOR SLABS</b>		
Buildings, pipe galleries, and other dry areas	S-1	S-B
Hydraulic channels	S-1	S-A
Underside of elevated slabs	S-3	S-A
<b>BEAMS AND COLUMNS</b>		
Beams/not coated	B-2	B-A
Columns/not coated	C-2	C-A

**END OF SECTION**

**PART 1 – GENERAL**

**1.01 DESCRIPTION**

- A. The WORK specified in this Section includes the requirements for mass concrete and mass concrete placement for sections equal to or in excess of 4 feet in thickness as designated in the Contract.

**1.02 DEFINITIONS**

- A. Mass Concrete: Any volume of concrete with dimensions large enough to require that measures be taken to cope with generation of heat of hydration of the cement and attendant volume change, to minimize cracking.
- B. References
  - 1. American Concrete Institute (ACI)
    - a. 207.1R – Mass Concrete
    - b. 207.2R - Effect of Restraint, Volume Change, and Reinforcement on Cracking of Mass Concrete
    - c. 207.4R - Cooling and Insulating Systems for Mass Concrete
    - d. 214.77 – Recommended Practice for Evaluation of Strength Test Results of Concrete

**1.03 SUBMITTALS**

- A. Comply with the requirements of Section 01300, SUBMITTAL PROCEDURES and additional requirements in this Section.
- B. Shop Drawings, Samples, and Technical Data: As a minimum, submit the following items:
  - 1. Product Data.
  - 2. Concrete mix design signed by a qualified mix designer. Concrete shall be proportioned to obtain workable mixes for the purpose intended with the minimum amount of cement and fly ash to adequately meet the strength and finish requirements.
  - 3. Laboratory test mix results signed by a qualified mix designer.
  - 4. Gradation of coarse and fine aggregates, and a combined gradation of coarse and fine aggregates. Use maximum size of coarse aggregate which is readily available.
  - 5. Temperature Control Plan that considers the expected ambient temperature at the time of concrete placement and maximum temperatures within the concrete. The plan is to include the following:

- a. Temperature monitoring system including manufacturer's information on sensing devices and data recorder, and plan showing the location of sensing devices.
  - b. Calculations on the expected maximum temperature, temperature rise and temperature differential for each large concrete placement. Maximum weighted average concrete placement temperature shall not exceed 80 degrees F. Peak temperature of the concrete after placement shall not exceed 135 degrees F.
  - c. Special requirements to reduce the effected of ambient temperature on the concrete at the time of placement.
  - d. Curing procedures.
- C. Submit Concrete Placement Plan for all large concrete placements one month prior to the concrete placement. Represent as accurately as possible the expected conditions at the time of the concrete placement. The plan is to include the following:
- 1. Volume of concrete to be placed and expected duration.
  - 2. Schedule identifying all critical activities and list start time, duration and expected finish.
  - 3. Number of concrete trucks required. Travel route from mixing plant to site. Identify any traffic mitigation measures to be taken to avoid potential disruption to the scheduled delivery of the concrete.
  - 4. Production rate of mixing plant.
  - 5. Method of concrete placement including anticipated interruptions and time intervals between lifts.
  - 6. Expected ambient temperature at time of placement and ambient temperature variation during cooling period.
  - 7. Curing procedures.

**1.04 QUALITY ASSURANCE**

- A. Comply with the requirements in Section 03300, CAST-IN PLACE CONCRETE.

**PART 2 – PRODUCTS**

**2.01 EQUIPMENT (NOT USED)**

**2.02 MATERIALS**

- A. Cement: Furnish from one source.
  - 1. Portland Cement Type II or Type IV

- a. Tricalcium Aluminate Content of Cement: Maximum 8 percent.
  - b. Sum of Tricalcium Aluminate and Tricalcium Silicate: Maximum 58 percent.
  - c. Provide chemical and physical properties from cement supplier upon request by OWNER'S REPRESENTATIVE.
- B. Coarse Aggregate:
- 1. Size: Maximum 1-1/2 inches.
  - 2. Grading: Conform to the requirements of Table 2.5.8, ACI 207.1R.
  - 3. Conform to the requirements of Section 03300, CAST-IN PLACE CONCRETE.
- C. Fine Aggregate:
- 1. Conform to the requirements of Section 03300, CAST-IN PLACE CONCRETE.
- D. Concrete Admixtures:
- 1. Water Reducing Admixture: Conform to the requirements of Section 03300, CAST-IN PLACE CONCRETE
  - 2. Pozzolan (Fly Ash Type F): Conform to the requirements of Section 03300, CAST-IN PLACE CONCRETE
    - a. Provide chemical and physical properties from fly ash supplier upon request by OWNER'S REPRESENTATIVE.
- E. Water:
- 1. Use mixing water that conforms to the requirements of Section 03300, CAST-IN PLACE CONCRETE

**2.03 CONCRETE MIX DESIGN**

- A. Design: Select and proportion ingredients using laboratory trial mixes. Sample, cure and test laboratory trial mix through an accredited testing laboratory. Submit laboratory test results on the trial mix to the OWNER'S REPRESENTATIVE prior to concrete placement.
- 1. Concrete Compressive Strength, f'c
    - a. Concrete compression strength f'c shall be 4,000 psi at 56 days, or 6000psi at 56 days where indicated on drawings.
    - b. Design lab-cured trial mix cylinders.

- c. Use additional cement or cement plus fly ash to meet average compressive strength,  $f'_{cr}$ . The weight of fly ash shall not exceed 35 percent of the total weight of cement and fly ash combined.
  - d. Use  $f'_{cr}$  as basis for selection of concrete proportions.
  - e.  $f'_{cr} = f'_c/(1-tV)$  or  $f'_{cr} = f'_c + t\sigma$  in accordance with ACI 214 section 4.1, where  $t = 1.04$ . Adopt  $t\sigma = 700$  psi when data is not available to establish standard deviation or coefficient of variation.  $f'_{cr}$  will be adjusted in function of the standard deviation/coefficient of variation obtained during operations.
  - f. Concrete shall have sufficient early strength for form support removal.
- B. Proportions:
- 1. Water-Cement Ratio: Maximum of 0.50.
  - 2. Entrained Air Content: Maximum of 4.0 percent at time of placement.
  - 3. Slump: 3 inches to 5 inches at placement.
  - 4. Fly Ash: Maximum 25 percent, minimum 15 percent of total weight of fly ash plus cement.

**2.04 CONCRETE MIXING**

- A. Comply with the requirements of Section 03300, CAST-IN PLACE CONCRETE.

**PART 3 – EXECUTION****3.01 PLACING CONCRETE**

- A. Comply with the requirements of Section 03300, CAST-IN PLACE CONCRETE except as modified herein.
- B. Allow concrete to reach maximum temperature rise before proceeding with the placement of successive mass concrete lifts.

**3.02 TEMPERATURE CONTROL**

- A. General:
- 1. At the time of concrete placement, have temperature control measures in place to limit the maximum initial concrete temperature to 80 degrees F.
  - 2. Install a temperature monitoring system to measure temperatures within the interior and the surface of the concrete. Provide two sets of three sensors for every 500 cubic yards of concrete being placed. The devices must operate in the range of 32 degrees F to 212 degrees F with an accuracy of  $\pm 2$  degrees F.

Temperatures are to be recorded automatically or manually as approved by the OWNER'S REPRESENTATIVE.

3. Do not place mass concrete until the OWNER'S REPRESENTATIVE has provided written approval of the Temperature Control Plan.
- B. Pre-Cooling of the Concrete Mix: The concrete mix may be pre-cooled prior to placement as follows:
1. Cool batch water.
  2. Store all aggregates to prevent heat absorption and heating by direct sunlight.
  3. Spray coarse aggregate stockpiles with water for an evaporative cooling effect.
  4. Place mass concrete later in the evening, over night, or in the early morning hours.
  5. Alternative methods may be used if approved by the OWNER'S REPRESENTATIVE.
- C. Curing:
1. Water cure the concrete as soon as possible after placement in accordance with the requirements of Section 03370, CONCRETE CURING.
- D. Temperature Monitoring
1. Continuously monitor the temperature of the interior and surface of the concrete for at least 60 days after placement. Submit data to the OWNER'S REPRESENTATIVE daily.

**END OF SECTION**

**SECTION 03305  
SHOTCRETE**

**PART 1 - GENERAL**

1.01 DESCRIPTION

- A. This section specifies the requirements to furnish, batch, mix, transport, place, finish, and test shotcrete for slope stabilization.
- B. Related work specified elsewhere:
  - 1. Section 03210: Concrete Reinforcement.
  - 2. Section 03300: Cast-In-Place Concrete.
- C. Definitions:
  - 1. Dry-mix Shotcrete: Shotcrete in which a pre-mixed blend of dry cement and aggregate is propelled through a hose by compressed air to a nozzle. Water is added to the cement and aggregate mixture at the nozzle and the mixed ingredients are projected onto the surface. Accelerator is added to the shotcrete mixture at the nozzle in such a way that the quantity can be properly regulated and monitored.
  - 2. Wet-mix Shotcrete: Shotcrete in which all the ingredients, except accelerator, are mixed before introduction into the delivery hose. Accelerator is added to the shotcrete mixture at the nozzle in such a way that the quantity can be properly regulated and monitored.
  - 3. Rebound: Shotcrete constituents that fail to adhere to the surface to which shotcrete is being applied.
  - 4. Shotcrete: A pneumatically applied mixture of Portland cement, aggregate, and water, conveyed through a hose and projected at high velocity onto a surface. The mixture contains admixtures to provide a quick set, high early strength, and satisfactory adhesion. Shotcrete may be of the ready-mix “wet” type, or “dry” mix type where water is added at the spray nozzle.

1.02 SYSTEM DESCRIPTION

- A. Design Criteria:
  - 1. Compressive strength:
    - a. Shotcrete used for excavation support:

- (1) 4,000 psi at 28 days.
  - (2) 2000 psi at 3 days.
  - (3) 1500 psi at 24 hours.
2. Additional Design Requirements:
- a. Use at least 5 percent silica fume but no more than 10 percent of cement weight.
  - b. Use a water/cement ratio of no more than 0.45.
  - c. First-crack flexural stress: In accordance with ASTM C1018.
  - d. Residual stress at given mid span deflections: In accordance with ASTM C1018, with deflections ranging between 0.02 inches and 0.079 inches for the shotcrete.

### 1.03 SUBMITTALS

- A. General: Make submittals in accordance with Section 01330.
- B. Product Data:
1. Applicable manufacturers' instructions, recommendations, literature, and performance and test data for:
    - a. Materials.
    - b. Mixing and application equipment.
    - c. Samples for testing.
  2. Material Safety Data Sheets for all materials to be incorporated into the mix.
- C. Working Drawings and Methods Statements:
1. Proposed methods for cleaning surfaces to receive shotcrete without causing undue erosion of the surface.
  2. Methods for controlling and diverting water inflows from surfaces receiving shotcrete.
  3. Proposed methods and equipment for proportioning, mixing, conveying, applying, curing, and testing shotcrete.
- D. Mix Designs:
1. Types and proportions of ingredients for each proposed shotcrete mix.
  2. Laboratory test results for each trial mix.

E. Quality Control:

1. Qualifications:

- a. Foreman's experience.
- b. Nozzlemen's qualifications and certifications.

2. Certifications:

- a. Testing laboratory performing shotcrete testing.
- b. Certification of specified shotcrete materials to the required standards.
- c. Manufacturer certification for proposed admixtures with regard to:
  - (1) Sequence and method of incorporation into a shotcrete mix.
  - (2) Their compatibility with the individual shotcrete materials and the shotcrete mix as a whole.
  - (3) Documented history of demonstrated satisfactory performance in a mix of similar proportions.

3. Quality Control Plans:

- a. Quality control plan for the monitoring of shotcrete operations to ensure compliance with specified requirements.

4. Recordkeeping:

- a. Test Reports: Submit preconstruction testing reports at least two weeks prior to applying shotcrete to any surface forming a part of the work. Submit field quality control testing reports within two working days of performing the tests. Provide the following information for all test reports:
  - (1) Sample identification, including mix design, test panel number and orientation, and identification of nozzleman.
  - (2) Date and time of sample preparation, including curing conditions, curing period, and sample dimensions.
  - (3) Date, time, and type of test.
  - (4) Strength of each core specimen.
  - (5) Measured strain at failure of each core specimen.
  - (6) Name and signature of individual performing the test.
- b. Shotcrete Production and Application Reports: Prepare and submit for each shift no later than the beginning of the following work day:
  - (1) Date, time, quantity (surface area and volume through the nozzle), and location of shotcrete applied, with sketches.
  - (2) Observations during production and application.

- (3) Description of placement equipment.
- (4) Batch number(s), if applicable.
- (5) Maximum and minimum air temperature.
- (6) Description of any special conditions or problems encountered.
- (7) Name of nozzleman and foreman's name and signature.

#### 1.04 QUALITY ASSURANCE

##### A. Reference Standards:

1. American Concrete Institute (ACI):
  - a. ACI 211.1, Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
  - b. ACI 214, Recommended Practice for Evaluation of Strength Test Results of Concrete.
  - c. ACI 301, Specifications for Structural Concrete for Buildings.
  - d. ACI 506R, Guide to Shotcrete.
  - e. ACI 506.2, Specification for Shotcrete.
  - f. ACI 506.3R, Guide to Certification of Shotcrete Nozzleman.
  - g. ACI 506.4R, Guide for the Evaluation of Shotcrete.
2. American Society for Testing and Materials (ASTM):
  - b. ASTM C31, Practice for Making and Curing Concrete Test Specimens in the Field.
  - c. ASTM C39, Compressive Strength of Cylindrical Concrete Specimens.
  - d. ASTM C42, Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
  - e. ASTM C192, Making and Curing Concrete Test Specimens in the Laboratory.
  - f. ASTM C311, Method for Sampling and Testing Fly Ash or Natural Pozzolans for use as a Mineral Admixture in Concrete.
  - g. ASTM C494, Specification for Chemical Admixtures for Concrete.
  - h. ASTM C1102, Time of Setting of Portland Cement Pastes Containing Accelerating Admixtures for Shotcrete.
  - i. ASTM C1140, Practice for Preparing and Testing Specimens from Shotcrete Test Panels.
  - j. ASTM C1141, Standard Specification for Admixtures for Shotcrete.

- k. ASTM C1240, Standard Specification for Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout.
  - l. ASTM E329, Practice for Use in the Evaluation of Testing and Inspection Agencies as Used in Construction.
- B. Qualifications:
  - 1. Shotcrete nozzleman:
    - a. Certified in accordance with ACI 506.3R.
    - b. Previous experience or training in the application of shotcrete on at least two projects of comparable nature.
    - c. Under the immediate supervision of a foreman with at least three years direct shotcrete application experience on comparable projects.
  - 2. The independent testing laboratory:
    - a. Certified compliant with the recommended requirements of the American Council of Independent Laboratories or ASTM E329.
    - b. Experience in performing the laboratory tests required herein.
- C. Acceptance Criteria:
  - 1. Conform to ACI 506.4R.
- D. Preconstruction Meeting:
  - 1. Hold a shotcrete pre-construction meeting at least 5 days but not more than 30 days prior to the first shotcrete application to review and discuss:
    - a. Approved mix designs.
    - b. Placing procedures.
    - c. Safety procedures.
    - d. Quality control procedures and quality assurance requirements.
    - e. Other shotcrete related issues as may be raised by either party.
- E. Training: (NOT USED)
- F. Testing:
  - 1. Mix and Field Trials:
    - a. Verify that proposed mix designs meet the strength criteria specified herein. Demonstrate the capability of the equipment, workmanship, and materials to produce acceptable quality shotcrete under field conditions, as determined by inspection and laboratory tests of samples taken from field

- trial test panels. Perform preconstruction field trials and laboratory testing in a manner that demonstrates the ability to meet these requirements.
- b. Conduct field trials in the presence of the Owner's Representative to demonstrate individual and integrated capability of equipment, workmanship, and materials under field conditions:
    - (1) Perform trials at least 45 days prior to starting production shotcrete operations.
    - (2) Construct test panels in accordance with ACI 506R.
    - (3) Orient test panels to simulate application to excavation face.
    - (4) Shotcrete a minimum of three test panels to the design thickness for each mix design proposed, and by each nozzleman proposed to perform the work.
    - (5) Cure test panels in accordance with ASTM C31, except that the panels shall not be immersed.
  - c. Take samples for testing. Provide one set of samples to the Owner's Representative. Take cores from each test panel in accordance with ASTM C42 and trim ends to comply with length to radii ratio requirements.
    - (1) Identify specimens by mix designation, time of placement, and test panel number.
    - (2) Moist cure but do not immerse samples from the time taken until the time tested.
  - d. Perform laboratory testing of samples taken from field trial panel samples to verify design requirements:
    - (1) Test cores within one day of coring.
    - (2) Perform cylinder testing for compressive strength on 6 samples (3 per panel) at 7 days and 28 days.
  - e. Ensure that all specified requirements are satisfied by the field trials for a particular mix design as a condition precedent to the approval of that mix design:
    - (1) The compressive strength of each core for a particular mix design from test panels shall meet or exceed the specified compressive strength for each curing age. Mixes failing to meet this requirement will be rejected.
2. Production Quality Control and Testing: Sample and test shotcrete placed during the progress of the work as specified in Part 3 of this Section.

## 1.05 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Perform in accordance with ACI 506R and manufacturer's recommendations.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS**

- A. Cement: Use Type II cement conforming to the requirements of Section 03300.
- B. Aggregates: Conform to the requirements of Section 03300, however the gradation and maximum size of the aggregate may be varied subject to Owner's Representative's approval and the results of preconstruction field trials.
- C. Water: Conform to the requirements of Section 03300.
- D. Admixtures conforming to the requirements of ASTM C1141, Section 03300, and the following:
  - 1. Admixtures shall not contain chlorides or materials corrosive to steel.
  - 2. Admixtures shall be compatible with any other admixtures proposed and with the cement used.
  - 3. Accelerators shall be:
    - a. Added at the nozzle.
    - b. Fluid.
    - c. Demonstrated to be compatible with the type and batch of cement used.
    - d. Dosage:
      - (1) Substitution of cement by accelerator materials shall not exceed 4 percent by weight of the total cementitious materials.
      - (2) Shall be dispensed by calibrated means at dosage rates not exceeding the maximum recommended by the manufacturer or specified herein.
  - 4. Hydration control admixtures shall not cause a decrease in concrete strength with age.
- E. Curing Compound: Conform to the requirements of Section 03370.
- F. Welded Wire Fabric Reinforcement: Refer to Section 03210.
- G. Steel Reinforcement: Refer to Section 3210.

### **2.02 EQUIPMENT**

- A. Batch Plant: Comply with the requirements of Section 03300.
- B. Mixers and Agitators: Comply with the requirements of Section 03300.
- C. Utilize shotcrete equipment capable of:
  - 1. Feeding materials at a regular rate.
  - 2. Maintaining steady air and water pressure without pulsation.

3. Ejecting shotcrete from the nozzle:
  - a. At velocities that will allow adherence of the materials to the surface being shotcreted with a minimum of rebound and maximum adhesion and density.
  - b. At pressures and volumes recommended by the manufacturer of the machine.
  - c. Without contamination from oil or foreign matter.
- D. Arrange placing equipment so that the nozzleman may use air and water in any combination to prepare surfaces for shotcreting or to clean the completed work.
- E. Store a sufficient number and type of spare parts at the construction site in order to minimize interruptions of the shotcreting operations due to shotcrete equipment or distribution system breakdown.

### 2.03 SOURCE QUALITY CONTROL

- A. Comply with the requirements of Section 03300.

## **PART 3 - EXECUTION**

### 3.01 GENERAL

- A. The Contractor is responsible for the design of all shotcrete mixes and for the quality of the shotcrete placed in the work.
- B. The same type and proportions of ingredients approved in the preconstruction field trials shall be used in the work areas for which they were approved. Do not modify or vary proportions without the Owner's Representative's prior written approval.

### 3.02 PREPARATION

- A. Clean surfaces to receive shotcrete, including previously shotcreted surfaces, of oil, grease, loose materials, mud, and other foreign matter by using a combination of water and high velocity air jet, or other approved means that does not cause undue erosion of the surface.
- B. Verify that reinforcement installed prior to shotcreting was installed in accordance with specification requirements.
- C. Maintain receiving surfaces in a moist condition from the time cleaning is completed until shotcrete is placed.
- D. Cover and protect all geotechnical instrumentation that will be affected by the shotcrete operation.

### 3.03 PROPORTIONING

- A. Dry Mix Process: Maintain the moisture content of the fine aggregate in the range of

three to six percent of the oven-dry weight of the aggregate at time of batching.

- B. Rebound: Do not re-use shotcrete rebound.

### 3.04 JOINT CONSTRUCTION

- A. Use the following joint treatments whenever the application of shotcrete is interrupted or stopped for a period of time that allows the in-place shotcrete to set or harden:
  - 1. Provide tapered construction joints. Do not construct square construction joints.
  - 2. Prior to applying shotcrete:
    - a. Thoroughly wet the surface of joints.
    - b. Clean the tapered section and adjacent surface.

### 3.05 PLACEMENT

- A. Place in accordance with ACI 506R.

### 3.06 CURING

- A. Protect and cure shotcrete in accordance with ACI 506R and ACI 506.2.
- B. Shotcrete surfaces shall be kept moist and covered whenever:
  - 1. The ambient temperature where shotcrete is exposed reaches or exceeds 80°F at any time during curing.
  - 2. The relative humidity where shotcrete is exposed falls below 70 percent.

### 3.07 SURFACE FINISH

- A. Gun finish “as shot” conforming to the general shape of the ground surface with some smoothing due to filling of irregular or over-excavated areas.
- B. Clean and patch holes in shotcrete using a non-shrink concrete or grout mix of the same strength as the surrounding material.

### 3.08 DEFECTIVE SHOTCRETE

- A. Defective shotcrete is shotcrete not conforming to the acceptance criteria specified in Part 1 of this Section.
- B. The Owner’s Representative reserves the right to direct the application of additional shotcrete to cover defective areas or the removal of defective shotcrete and its replacement with acceptable shotcrete, all at no additional cost to the City.
- C. If the Owner’s Representative determines that the Contractor's selected shotcreting application process fails to provide in-place shotcrete conforming to the

requirements of this Section, change to another system employing either of the two application processes at no additional cost to the City.

### 3.09 FIELD QUALITY CONTROL

- A. General: Identify specimens by mix designation and location where sample was taken. For samples taken from a test panel, additionally identify the test panel number and orientation.
- B. Thickness:
  - 1. Verify that shotcrete is being placed to the minimum required thickness by installing depth pins on a 6-foot by 6-foot pattern with no less than two pins per increment of surface area to receive shotcrete.
  - 2. The Contractor may propose other shotcrete thickness measurement methods for Owner's Representative's consideration and acceptance.
- C. Soundness: Inspect each shotcrete layer during and after application. Inspect visually and by sounding with a hammer after curing. Consider drummy-sounding shotcrete to be potentially defective shotcrete and request that the Owner's Representative perform further testing.
- D. Compressive Strength: Test the production shotcrete by obtaining in-place cores of the completed works, or by taking cores from production test panels that are prepared in accordance with Part 1 of this Section. Prepare and test cores as follows:
  - 1. Take core specimens in accordance with the requirements of ASTM C42 with a length to diameter ratio of 1.0. Air cure in an environment where relative humidity is 70 percent.
  - 2. Test core specimens at times determined by the Owner's Representative, in accordance with the requirements of ASTM C39. Do not test cores with obvious defects, but obtain sound replacement cores for testing.
  - 3. Frequency of Compressive Strength Testing:
    - a. During the first three shifts of shotcrete placement and for each specific nozzleman: Take three test core specimens for each 6 cubic yards of shotcrete placed. Perform unconfined compression testing of these cores at 1 day, 7 day, and 28 day intervals.
    - b. All other shotcrete placement: Take three test core specimens for each 40 cubic yards of shotcrete placed. Perform unconfined compression testing of these cores at 1 day, 3 day, and 28 day intervals.
    - c. When the Owner's Representative determines defective shotcrete has been placed, based on field observations. Perform this work at no additional cost to the City for taking and sampling specimens, and for patching the holes if sampling and subsequent inspection indicates that the shotcrete meets specified requirements.
  - 4. Evaluate the compressive strength of the shotcrete in accordance with ACI

214.

5. Where the Owner's Representative determines that testing has demonstrated a constant and satisfactory relationship, the Owner's Representative may consider utilizing the compressive strength of samples taken from the concrete delivered to the site and tested in accordance with ASTM C31 and ASTM C39 as an alternative to testing of core from placements.
6. If a test core does not meet one or more of the compressive strength requirements specified herein, the Owner's Representative may require additional testing, additional thickness of shotcrete, or removal and replacement with new shotcrete, at no additional cost to the Owner.

**END OF SECTION**

**PART 1 – GENERAL**

**1.01 DESCRIPTION**

- A. The WORK specified in this Section includes the requirements for curing of concrete as designated in the Contract.

**1.02 DEFINITIONS**

- A. References
  - 1. American Society for Testing and Materials (ASTM)
    - a. C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing concrete.
    - b. C131 – Standard Specification for Liquid Membrane-Forming Compounds having Special Properties for Curing and Sealing Concrete.

**1.03 SUBMITTALS**

- A. Provide submittals in accordance with the requirements Section 01300, SUBMITTAL PROCEDURES, and additional requirements in this Section.
- B. Shop Drawings
  - 1. Curing methods proposed.
  - 2. Manufacturers' data for the following products:
    - a. Evaporation retardant.
    - b. Curing compound.
- C. Quality Control Submittals
  - 1. Curing Compound: Manufacturer's Certificate of Compliance showing moisture retention requirements.

**PART 2 – PRODUCTS**

**2.01 EQUIPMENT (NOT USED)**

**2.02 MATERIALS**

- A. Curing Compound
  - 1. Water-based, high solids content non-yellowing curing compound meeting requirements of ASTM C309 and C1315.
    - a. Moisture Loss: 0.40 kg/square m/72 hours maximum.
    - b. Capable of meeting moisture retention at manufacturer's specified application rate.
  - 2. Manufacturers and Products
    - a. Chemrex, Inc., Shakopee, MN; Masterkure
    - b. Euclid Chemical Co., Cleveland, OH; Super Diamond Clear VOX
    - c. WR Meadows, Inc., Hampshire, IL; VOCOMP-30
    - d. Vexcon Chemical, Inc.; Philadelphia, PA; Starseal 1315
    - e. Dayton Superior; Safe Cure and Seal 30 percent.
- B. Evaporation Retardant
  - 1. Optional: Fluorescent color tint that disappears completely upon drying.
  - 2. Manufacturers and Products
    - a. Master Builders Co., Cleveland, OH; CONFILM
    - b. Euclid Chemical Co., Cleveland, OH; Eucobar
- C. Water: Clean and potable, containing less than 500 ppm of chlorides.

**PART 3 – EXECUTION****3.01 CURING OF CONCRETE**

- A. Use one of the following methods as approved by OWNER'S REPRESENTATIVE:
  - 1. Walls
    - a. General: Where walls are to receive coatings, painting, cementitious material, or other similar finishes, or where solvent-based coatings are not permitted, use only water curing procedures.
    - b. Method 1: Leave concrete forms in place and keep entire surfaces of forms and concrete wet for seven days.
    - c. Method 2: Apply curing compound, where allowed, immediately after removal of forms.

- d. Method 3: Continuously sprinkle with water 100 percent of exposed surfaces for seven days starting immediately after removal of forms.

2. Slabs and Curbs

- a. Method 1: Protect surface by water ponding for seven days.
- b. Method 2: Cover with burlap or cotton mats and keep continuously wet for 7 days.
- c. Method 3: Cover with one inch layer of wet sand, earth, or sawdust, and keep continuously wet for seven days.
- d. Method 4: Continuously sprinkle exposed surface for seven days.
- e. Other agreed upon method that will keep moisture present and uniform at all times on surface of slabs. Do not use curing compounds unless approved by OWNER'S REPRESENTATIVE.
- f. Where water curing for slabs during cold weather is not possible, use an OWNER'S REPRESENTATIVE approved curing compound at manufacturer's recommended coverage per gallon.
- g. Where curing compound cannot be used, special methods using moisture shall be agreed upon prior to placing the concrete slabs.
- h. Protect slabs during cold weather with plastic sheets or other material inside required heated enclosure if foot traffic is permitted on slabs.

**3.02 EVAPORATION RETARDANT APPLICATION**

- A. Spray onto surface of fresh flatwork concrete immediately after screeding to react with surface moisture.
- B. Reapply as needed to ensure a continuous moist surface until final finishing is completed.

**3.03 MANUFACTURER'S SERVICES**

- A. Provide curing compound manufacturer's representative on site to demonstrate proper application of curing compound to show coverage in one coat.

**END OF SECTION**

**PART 1 – GENERAL**

**1.01 DESCRIPTION**

- A. This WORK specified in this Section includes the requirements for fabricating, furnishing and installing precast concrete units as designated in the Contract Documents. WORK also includes all erection hardware and miscellaneous hardware required to connect units to adjacent construction.

**1.02 DEFINITIONS**

- A. References
1. American Concrete Institute (ACI)
    - a. 318 – Building Code Requirements for Reinforced Concrete
  2. American Society for Testing and Materials (ASTM)
    - a. C150 – Standard Specification for Portland Cement
  3. American Welding Society (AWS)
    - a. D1.1 – Structural Welding Code – Steel
  4. Prestressed Concrete Institute (PCI)
    - a. Plant Certification Program
    - b. MNL-117 – Manual For Quality Control for Plants and Production of Architectural Precast Concrete Products, Third Edition

**1.03 DESIGN REQUIREMENTS**

- A. Precast items shall be designed for dead loads, live loads, groundwater, the actual mechanical equipment to be supported, and soil loading. Summary loadings are as follows:
1. Dead loads:
    - a. Actual dead load of vault, cover, additional cover concrete and/or paving, and other dead loads indicated on the Drawings.
    - b. Collateral cover dead load of ten pounds per square foot.
  2. Live loads:
    - a. HS20 traffic loading on lid or cover, typical.

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- b. Adjacent vertical load on soil of 250 pounds per square foot, transmitted laterally into walls using an at rest coefficient of 0.55.
- 3. Soil and groundwater:
  - a. Soil loading based on 120 pound per cubic foot density and at rest lateral coefficient of 0.55.
  - b. Typically assume groundwater at grade, design to resist flotation using a factor of safety 1.5. Calculations shall indicate conformance to this requirement. Uplift resistance may be provided by vault's dead load, weight of surrounding soil acting directly downward on extended base lips, and soil friction acting on a vertical plane all around the base lips to the surface equal to  $14 \times H^2$  pounds per lineal foot of perimeter where H equals depth to top of base slab.

**1.04 SUBMITTALS**

- A. Comply with the requirements of Section 01300, SUBMITTAL PROCEDURES, and as specified herein.
- B. Shop Drawings: Submit shop drawings showing the following:
  - 1. Number and type of members, with dimensions and skew angles of each.
  - 2. Quantities, dimensions, and locations of sleeves, anchors, inserts, reinforcing steel bars, and lifting and erection pads, and methods of securing same in forms.
  - 3. Estimated camber.
  - 4. Detailed casting, consolidating, and finishing procedures.
  - 5. All other information required for proper fabrication of the members.
  - 6. Concrete design mix, with method and time of curing.
- C. Certificates
  - 1. Submit evidence of current plant certification under the PCI Plant Certification Program.
  - 2. Submit manufacturers' certifications for materials as required by PCI MNL-117.
  - 3. Submit welding certificates and procedures in accordance with AWS D1.1.
- D. Deviations from Design
  - 1. Design deviations are permitted only after the OWNER'S REPRESENTATIVES' written approval of the manufacturer's proposed design

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supported by complete design calculations and drawings, and stamped by a Professional Engineer registered in the State of Oregon.

2. Design deviations must provide an installation equivalent to the basic intent.

**1.05 QUALITY CONTROL**

- A. General: Comply with PCI MNL-117.
- B. Qualifications of Fabricator
  1. Plant Certification: The fabrication plant is an active and approved participant in the PCI Plant Certification Program.
  2. Welders are qualified in accordance with AWS D1.1 within the preceding year.
- C. Requirements of Regulatory Agencies. All local codes plus the following specifications, standards, and codes are a part of these Specifications:
  1. ACI 318 – Building Code Requirements for Requirements for Reinforced Concrete
  2. AWS D1.1 – Structural Welding Code-Steel

**PART 2 – PRODUCTS**

**2.01 EQUIPMENT (NOT USED)**

**2.02 MATERIALS**

- A. Concrete Mix Design: Concrete used to construct precast items shall conform to standard ACI practices and the following:
  1. 28-day strength,  $f'c = 5,000$  psi minimum.
  2. Type I, II, or V cement.
  3. Class F flyash pozzolan may be used at CONTRACTOR'S option, up to 20 percent of total cementitious content.
  4. Maximum water cement ratio 0.42, including pozzolan content.
  5. Maximum coarse aggregate size 3/4 inch, one inch, or 1-1/2 inch at CONTRACTOR'S option.
  6. Water reducing admixtures may be used to adjust slump.

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7. If concrete is exposed to weather, provide admixture to result in 5 percent entrained air, +1 percent, -0.5 percent.
- B. Reinforcing Steel: Provide deformed bar reinforcing conforming to ASTM A615, Grade 60 and welded wire fabric conforming to ASTM A185. Reinforcing to be welded shall conform to ASTM A706.
- C. Embedded Items and Anchorage Devices: All embedded items, inserts, and anchorage devices shall be Type 316 stainless steel. Anchorage devices shall be fabricated from Type 316 stainless steel. This requirement does not apply to access hatches.

Adhesive anchors shall be utilized typically, unless mechanical (wedge) anchors approved by OWNER'S REPRESENTATIVE for particular installations. Overhead applications shall use capsule anchors designed for such geometry.

Acceptable products include:

1. Adhesive Anchors: Hilti HY150 Injection Adhesive Anchor.
  2. Capsule Anchors: Hilti HVA system utilizing HVU foil capsule.
  3. Wedge Anchors: Hilti Kwik-Bolt II.
  4. Equivalent products may be utilized after review of ICBO Evaluation Report demonstrating required strength.
- D. Nonshrink Grout: Nonshrink grout acceptable manufacturers and products include Five Star Products, Inc. Five Star Grout, Master Builders Masterflow 713, and Burke Company Non-Ferrous, Non-Shrink Grout, or equal.
  - E. Expanding (Hydrophilic) Waterstops: Expanding waterstops shall be bentonite-free and made from unvulcanized rubber. Acceptable products include SikaSwell or SikaSwell Profile by SIKA, and Adeka. Equivalents approved by the OWNER'S REPRESENTATIVE are acceptable. Provide adhesive approved by the waterstop manufacturer where required due to geometry, irregular surface conditions, or as recommended by the manufacturer.
  - F. PVC Waterstops: PVC waterstops shall be manufactured from virgin polyvinyl chloride conforming to the Corps of Engineers Specification No. CRD-C572. Unless otherwise specified or noted on the drawings, waterstops in construction joints shall be six inch flat center/ribbed sides/0.375 inch thick, Greenstreak 679, Vinylex R6-38, or equal. Waterstops in expansion joints shall be nine inch center-bulb/ribbed sides/0.375 inch thick, Greenstreak 735, Vinylex RB9-38H, or equal.
  - G. Penetrations: All required penetrations and openings larger than 12 inches in diameter or 12 inches square shall be formed in place at the time of casting. Openings and penetrations 12 inches and smaller may be core drilled. Pipe penetrations and openings shall not be located within 12 inches of a concrete joint or seam. Additional reinforcing

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shall be added where required to meet loading requirements whether core drilled or formed. Water-tight, flexible connections shall be provided at all penetrations.

- H.    Molds: Material from which molds are to be fabricated shall be steel, concrete, fiberglass, reinforced plastic, or wood. The selection of materials for molds shall be at the manufacturer's option, except that wood shall not be used without the express approval of the OWNER'S REPRESENTATIVE. All elements shall be cast in molds of rigid construction, accurate in detail with precise corners and arises, and designed to provide a close control of dimensions and details as indicated on the drawings.

Prior to casting of precast elements, molds shall have all surface joints, radii, corners, etc., filled, ground, filed, straightened, or otherwise removed to provide a finished concrete surface that is smooth and dense, free of honeycombing, large air pockets, offsets, sinkages, or other irregularities.

- I.    Parting Compound: All molds shall be coated with parting compound to facilitate removal of elements from molds. Parting compound shall be non-petroleum, nonstaining and shall be of a nature and composition not deleterious to concrete.
- J.    Moisture Protection: All vaults shall be fabricated with joints designed to prevent intrusion of groundwater. Minimum joint waterproofing shall include an O-ring type seal or other approved gasket. Joints shall be shaped to allow exterior sealant application as specified below.
- K.    Miscellaneous Metal
1.    Miscellaneous metal items required within the precast and is provided by the precast concrete fabricator is to comply with requirements of Section 05500, MISCELLANEOUS METALS.
  2.    Anchors, Plates and Inserts: See Drawings for locations.

**2.03    MOISTUREPROOFING COATINGS**

- A.    All vaults shall be moistureproofed on exterior buried surfaces as specified below. Coating may be applied by the manufacturer and touched up in the field after installation but prior to backfill or entirely field applied at CONTRACTOR'S option.
- B.    Moistureproofing coating shall be epoxy resin. Candidate manufacturers for epoxy resin products include Tnemec Series 69, Ameron Amercoat 385, and International Protective Coatings Integard 760HS. Each of these is a polyamidoamine epoxy.

**2.04    POLYURETHANE SEALANT**

- A.    Polyurethane sealants shall be non-sag and conform to FEDSPEC TT-S-0230C, Type II, Class A. Primer shall be as recommended by the sealant manufacturer. Backer rod shall be open cell polyethylene or polyurethane foam. Rod shall be cylindrical unless otherwise specified. Backer tape shall be polyethylene or polyurethane with adhesive on one side.

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- B. Acceptable products shall be Sikaflex by Sika Chemical Corporation, Vulkem by Mameco International, U-Seal Joint Sealant by Burke Company, or Rubber Calk by Products Research and Chemical Corporation.

**PART 3 – EXECUTION**

**3.01 CONSTRUCTION**

- A. Manufacture
  - 1. General: Manufacture precast concrete units in accordance with PCI MNL-117, and as specified hereinafter.
- B. Transportation and Erection
  - 1. General: Transport, store, and erect precast concrete units in accordance with PCI MNL-117 and as specified herein.
  - 2. Handling: Maintain precast concrete unit in an upright position at all times. Handle units only by the indicated lifting pads, and in a manner, which will not overstress and damage the unit.

**3.02 INSTALLATION (NOT USED)**

**3.03 FINISHING**

- A. Finish concrete in accordance with the requirements in Section 03300, CAST-IN-PLACE CONCRETE.

**3.04 FIELD INSPECTION**

- A. Inspection: Examine all parts of the supporting structure and the conditions under which the precast concrete units are to be erected. Do not proceed with the installation until unsatisfactory conditions have been corrected.
- B. In addition to the applicable requirements of Section 03300, CAST-IN-PLACE CONCRETE, and PCI MNL-117, precast units may be rejected for any of the following reasons:
  - 1. Exceeding specified installation tolerances.
  - 2. Damage during construction operations.

**END OF SECTION**

**PART 1 – GENERAL**

**1.01 DESCRIPTION**

- A. The WORK in this Section includes the requirements for furnishing and installing grout for tie holes, blockouts, machine bases, column bases, and other applications as designated in the Contract.

**1.02 DEFINITIONS**

- A. References
  - 1. American Society for Testing and Materials (ASTM)
    - a. C230 – Standard Specification for Flow Table for Use in Tests of Hydraulic Cement
    - b. C1107 – Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
  - 2. Corps of Engineers (COE)
    - a. CRD-C611 – Flow of Grout for Preplaced Aggregate Concrete
    - b. CRD-C621 – Specification for Non-shrink Grout

**1.03 SUBMITTALS**

- A. Comply with the requirements of Section 01300, SUBMITTAL PROCEDURES and additional requirements in this Section.
- B. Shop Drawings
  - 1. Product data of grouts.
  - 2. Proposed method for keeping existing concrete surfaces wet prior to placing grout.
  - 3. Forming method for fluid grout placements.
  - 4. Curing method for grout.
- C. Quality Control Submittals
  - 1. Manufacturer's Written Instructions
    - a. Cement-water ratio of grout topping.
    - b. Mixing of grout.

2. Manufacturer's Certificate of Compliance
  - a. Grout free from chlorides and other corrosion-causing chemicals.
  - b. Nonshrink grout properties of Category II, verifying expansion at three or 14 days will not exceed the 28 day expansion and nonshrink properties are not based on gas or gypsum expansion.
3. Manufacturer's Certificate of Proper Installation.
4. Statements of Qualification: Nonshrink grout manufacturer's representative.
5. Test Reports
  - a. Test report for 24 hour evaluation of nonshrink grout.
  - b. Test results and service report from the demonstration and training session.
  - c. Field test reports and laboratory test results for field-drawn samples.

**1.04 QUALITY ASSURANCE**

- A. Qualifications
  1. Nonshrink Grout Manufacturer's Representative: Authorized and trained representative of grout manufacturer. Minimum of one year experience that has resulted in successful installation of grouts similar to those for this Project.
- B. Guarantee
  1. Manufacturer's guarantee is not to contain disclaimer on the product data sheet, grout bag, or container limiting responsibility to only the purchase price of products and materials furnished.
  2. Manufacturer guarantees participation in replacing or repairing grout found defective due to faulty materials, as determined by industry standard test methods.

**PART 2 – PRODUCTS**

**2.01 EQUIPMENT (NOT USED)**

**2.02 MATERIALS**

- A. Nonshrink Grout
  1. Category I
    - a. Nonmetallic and nongas-liberating.

- b. Prepackaged natural aggregate grout requiring only the addition of water.
  - c. Test in accordance with ASTM C1107
    - 1) Flowable consistency 140 percent, five drops in 30 seconds, in accordance with ASTM C230.
    - 2) Flowable for 15 minutes.
  - d. Grout will not bleed at maximum allowed water.
  - e. Minimum strength of flowable grout, 3,000 psi at three days, 5,000 psi at seven days, and 7,000 psi at 28 days.
  - f. Manufacturers and Products
    - 1) Chemrex, Inc., Shakopee, MN; Set Grout
    - 2) Euclid Chemical Co., Cleveland, OH; NS Grout
    - 3) Dayton Superior Corp., Miamisburg, OH; 1107 Advantage Grout
    - 4) US MIX Products, Denver, CO; US Spec Multi-Purpose Grout
    - 5) Or approved equal
2. Category II
- a. Nonmetallic, nongas-liberating.
  - b. Prepackaged natural aggregate grout requiring only the addition of water.
  - c. Aggregate shows no segregation or settlement at fluid consistency at specified times or temperatures.
  - d. Test in accordance with COE CRD-C621 and ASTM C1107, Grade B.
    - 1) Fluid consistency 20 to 30 seconds in accordance with COE CRD-C611.
    - 2) Temperatures of 40, 80, and 100 degrees F.
  - e. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.
  - f. Minimum strength of fluid grout, 3,500 psi at one day, 4,500 psi at three days, and 7,500 psi at 28 days.
  - g. Maintain fluid consistency when mixed in one to nine yard loads in ready-mix truck.

- h. Manufacturers and Products
  - 1) Chemrex, Inc., Shakopee, MN; Master Flow 928
  - 2) Five Star Products Inc., Fairfield, CT; Five Star 100
  - 3) Euclid Chemical Co., Cleveland, OH; Hi Flow Grout
  - 4) Dayton Superior Corp., Miamisburg, OH; Sure Grip High Performance Grout.
  - 5) Or approved equal.

**PART 3 – EXECUTION**

**3.01 CONSTRUCTION**

- A. General: Mix, place, and cure nonshrink grout in accordance with grout manufacturer's representative's training instructions.
- B. Nonshrink Grout Schedule
  - 1. Furnish nonshrink grout for applications in grout category in the following schedule or per manufacturer’s recommendations:

Application	Temperature Range	Max. Placing Time	
	40 to 100 deg F	20 min	Greater than 20 min
Filling tie holes	I	I	I
Blockouts for gate guides	I or II		II
Through-bolt openings	II	II	II
Patching concrete walls	II	II	II

- C. Form Tie or Through-Bolt Holes: Provide nonshrink grout, Category I and II, fill space with dry pack dense grout hammered in with steel tool and hammer. Through-bolt holes, coordinate dry pack dense grout application with vinyl plug in Section 03100, CONCRETE FORMWORK and bonding agent in Section 03300, CAST-IN-PLACE CONCRETE.

**3.02 INSTALLATION (NOT USED)**

**3.03 FIELD QUALITY CONTROL**

**A. Evaluation and Acceptance of Nonshrink Grout**

1. Provide a flow cone and cube molds with restraining plates onsite. Continue tests during Project as demonstrated by grout manufacturer's representative.
2. Perform flow cone and bleed tests, and make three two inch by two inch cubes for each 25 cubic feet of each type of nonshrink grout used. Use restraining caps for cube molds in accordance with COE CRD-C621.
3. For large grout applications make three additional cubes and one more flow cone test. Include bleed test for each additional 25 cubic feet of nonshrink grout placed.
4. Consistency: As specified in Subsection 2.02. Grout with consistencies outside range requirements will be rejected.
5. Segregation: As specified in Subsection 2.02. Grout when aggregate separates will be rejected.
6. Nonshrink grout cubes are to test equal to or greater than minimum strength specified.
7. Strength Test Failures: Remove and replace nonshrink grout WORK failing strength tests.
8. Perform bleeding test to demonstrate grout will not bleed.
9. Store cubes at 70 degrees F.
10. Independent testing laboratory is to prepare, store, cure, and test cubes in accordance with COE CRD-C621.

**3.03 MANUFACTURER'S SERVICES**

**A. General**

1. Coordinate demonstrations, training sessions, and applicable site visits with grout manufacturer's representative.
2. Provide and conduct onsite, demonstration and training sessions for bleed tests, mixing, flow cone measurement, cube testing, application, and curing for each category and type of nonshrink grout.
3. Make necessary equipment and materials available for demonstration.

- B. Training
1. Training is required for all Type II grout installations.
  2. Grout manufacturer's representative is to provide training necessary to perform grout WORK.
  3. Establish location at site and schedule time for grout manufacturer's demonstration and training session of proposed nonshrink grouts. Mix nonshrink grouts to required consistency, test, place, and cure on actual Project, e.g., baseplates and tie holes to provide actual on-the-job training.
  4. Mix grout to fluid consistency and conduct flow cone and two bleed tests, make a minimum of six cubes for testing of two cubes at one, three, and 28 days.
  5. Training is to include methods for curing grout.
  6. Mix and demonstrate patching through-bolt holes and blockouts for gate guides, and similar items.
  7. Transport test cubes to an independent test laboratory and obtain test reports.

**END OF SECTION**

**PART 1 – GENERAL**

**1.01 DESCRIPTION**

- A. The WORK specified in this Section includes the requirements for furnishing and installing concrete repair systems for the repair of defective concrete as designated in the contract.

**1.02 DEFINITIONS**

- A. Concrete Repair Systems
  - 1. Finishing: Leveling, smoothing, consolidating, and otherwise treating the surface of a repair to produce the desired appearance.
  - 2. Patching: Repair of distressed concrete including honeycombs, rock pockets, spalled areas, and other non-structural defects.
  - 3. Structural Repair: Repair to areas that are subject to structural loading or heavy wear and where defects or parts of defects extend 1 inch or deeper into the concrete.
  - 4. Crack Repair: Structural repairs to dry (non water producing) cracks in concrete structures.
- B. References
  - 1. American Association of State Highway Transportation Officials (AASHTO)
    - a. T237 – Standard Method for Testing Epoxy Resin Adhesive
  - 2. American Society for Testing and Materials (ASTM)
    - a. C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
    - b. C109 – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using two inch or [50-mm] Cube Specimens)
    - c. C348 – Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars
    - d. C496 – Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
    - e. C881 – Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

- f. C882 – Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear
  - g. D638 – Standard Test Method for Tensile Properties of Plastics
  - h. D695 – Standard Test Method for Compressive Properties of Rigid Plastics
  - i. D790 – Standard Test Methods for Flexural Properties of Un-reinforced and Reinforced Plastics and Electrical Insulating Materials
  - j. D2393 – Test Method for Viscosity of Epoxy Resins and Related Components
3. American Concrete Institute (ACI)
- a. 503 – Repairing Concrete with Epoxy Mortars

**1.03 SUBMITTALS**

- A. Comply with the requirements of Section 01300, SUBMITTAL PROCEDURES, and additional requirements in this Section.
- B. Qualifications
  - 1. Submit qualifications of the manufacturer(s) and firm(s) performing the application, demonstrating compliance with paragraph 1.04A of this Section.
  - 2. Certify that the material and procedures used are appropriate for the repair application.
- C. Manufacturer's Descriptive Brochures:
  - 1. Submit manufacturer's literature describing proposed products.
  - 2. Technical data for crack repair metering, mixing, and injection equipment.
- D. MSDS information for products
- E. Quality Control Submittals.
  - 1. Finishing, Patching, and Structural Repair: Manufacturer's recommended surface preparation procedures and application instructions.
  - 2. Crack Repair

- a. Manufacturer's recommended surface preparation procedures and application instructions for epoxy adhesives
  - b. Installation instructions for repairing core holes with epoxy grout.
  - c. Manufacturer's Certificate of Compliance: Certified test results for each batch of epoxy adhesive.
  - d. Statements of Qualification for Epoxy Adhesive
    - 1) Manufacturer's site representative.
    - 2) Injection applicator.
    - 3) Injection pump operating technician.
- F. Contract Closeout Submittals: Epoxy adhesive two component ratio, injection pressure, and crack injection test records for crack repair work.

**1.04 QUALITY ASSURANCE**

- A. Qualifications:
- 1. Structural Repair
    - a. Low-pressure spray equipment operator
      - 1) Certified by pump and spray equipment manufacturer.
      - 2) Minimum three years experience with structural repair systems.
  - 2. Crack Repair
    - a. Manufacturer's Site Representative
      - 1) Capable of instructing successful methods for restoring concrete structures using epoxy injection process.
      - 2) Understands and is capable of explaining technical aspects of correction material selection and use.
      - 3) Experienced in the operation, maintenance, and troubleshooting of application equipment.
    - b. Injection crew and job foreman shall provide written and verifiable evidence showing compliance with the following requirements:
      - 1) Licensed and certified by epoxy manufacturer.

- 2) Minimum of three years experience in successful epoxy injection for at least 10,000 linear feet of successful crack injection.
- B. Mockups: For all Concrete Repair Systems prepare an area as designated by the OWNER'S REPRESENTATIVE prior to execution of the WORK.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Finishing, Patching, and Structural Repair
1. Transport and store in unopened containers protected from moisture and dampness in a cool, clean, dry area between 45 and 90 degrees F.
  2. Do not stack bags more than two pallets high to avoid compression set.
- B. Crack Repair
1. Packing and Shipping: Package adhesive material in new sealed containers and label with the following information:
    - a. Manufacturer's name.
    - b. Product name and lot number.
    - c. ANSI Hazard Classification (formerly SPI Classification)
    - d. ANSI recommended precautions for handling.
    - e. Mix ratio by volume
  2. Storage and Protection: Store adhesive containers at ambient temperatures below 120 degrees F and above 32 degrees F.

**PART 2 – PRODUCTS**

**2.01 EQUIPMENT**

- A. Structural Repair: Low-pressure spray equipment as recommended by the repair mortar manufacturer.
- B. Crack Repair
1. Pumps
    - a. Portable, positive displacement type pumps with in-line metering to meter and mix two adhesive components, and inject mixture into crack.

- b. Electric or air powered with interlocks providing positive ratio control of proportions for the two components at nozzle.
  - c. Primary injection pump for each material of different mix ratio, including a standby backup pump of similar ratio.
  - d. Capable of immediate compensation for changes in resins.
  - e. Do not use batch mix pumps.
2. Discharge Pressure: Automatic pressure controls capable of discharging mixed adhesive at pressures up to 200 psi, plus or minus five percent, and able to maintain pressure.
  3. Automatic Shutoff Control: Provide sensors on both Component A and B reservoirs for stopping machine automatically when only one component is being pumped to mixing head.
  4. Proportioning Ratio Tolerance: Maintain epoxy adhesive manufacturer's prescribed mix ratio within a tolerance of plus or minus 5 percent by volume at discharge pressure up to 160psi.
  5. Ratio/Pressure Check Device
    - a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing valve to restrict material flow.
    - b. Pressure gauge capable of sensing pressure behind each valve.

**2.02 MATERIALS****A. Finishing**

1. Use a product that is a Portland cement based finish coating for featheredge applications.
2. Manufacturers and Products
  - a. Degussa Building Products, Shakopee, MN; Thorite Thin Surface Repair Mortar
  - b. Tamms Industries, Kirkland, IL; Concrete Finisher.
  - c. Approved Equivalent

- B. Patching
  - 1. Use a product that is a polymer modified repair mortar with the following properties:
    - a. Minimum Compressive Strength: 5,000 psi @ 28 days, ASTM C109
    - b. Minimum Flexural Strength: 1,200 psi @ 28 days, ASTM C348
    - c. Minimum Tensile Strength: 550 psi @ 28 days, ASTM C496
    - d. Minimum Direct Tensile Bond Strength: 200 psi @ 28 days, ACI 503
  - 2. Manufacturers and Products
    - a. Degussa Building Products, Shakopee, MN; EMACO R300 CI or EMACO R310 CI.
    - b. Sika Corp., Lyndhurst, NJ; SikaTop 122 Plus or SikaTop 123 Plus
    - c. Approved Equivalent
- C. Structural Repair
  - 1. Use a product that is a one-component, cement based, silica fume enhanced, fiber reinforced, shrinkage compensated repair mortar with the following properties:
    - a. Minimum Compressive Strength: 10,000 psi @ 28 days, ASTM C109
    - b. Minimum Flexural Strength: 1,100 psi @ 28 days, ASTM C348
    - c. Minimum Tensile Strength: 735 psi @ 28 days, ASTM C496
    - d. Minimum Direct Tensile Bond Strength: 300 psi @ 28 days, ACI 503
    - e. Free of chlorides and other chemicals causing corrosion.
  - 2. Manufacturers and Products
    - a. Degussa Building Products, Shakopee, MN; EMACO S88 CI.
    - b. Sika Corp., Lyndhurst, NJ; SikaRepair 224.
    - c. Approved Equivalent

**D. Crack Repair**

1. Use a two-component low-viscosity liquid epoxy adhesive that adheres to ASTM C881 and has the following properties:
  - a. Uncured
    - 1) Minimum Viscosity: 465 cps, ASTM D2393
  - b. Cured
    - 1) Minimum Compressive Strength: 10,000 psi @ 14 days, ASTM D695
    - 2) Minimum Flexural Strength: 5,400 psi @ 14 days, ASTM D790
    - 3) Minimum Tensile Strength: 7,900 psi @ 14 days, ASTM D638
    - 4) Minimum Direct Tensile Bond Strength: 1,500 psi @ 14 days, ASTM C882
    - 5) Minimum Elongation at Break: 2.5 percent, ASTM D638
2. Manufacturers and Products
  - a. Degussa Building Products, Shakopee, MN; SCB Concrecive 1380.
  - b. Sika Corp., Lyndhurst, NJ; Sikadur 52.
  - c. Approved Equivalent

**2.03 SOURCE QUALITY CONTROL**

- A. Structural Repair: Perform compressive strength tests in accordance with ASTM C109 for each batch of repair mortar.
- B. Crack Repair
  1. Test Requirements: Perform tests for each batch of adhesive.
  2. Pot Life Test
    - a. Condition Components A and B to required temperature.
    - b. Measure components in ratio of Component B as stated on manufacturer's label into an 8 fluid ounce paper cup.

- c. Start stopwatch immediately and mix components for 60 seconds using wooden tongue depressor, take care to scrape sides and bottom of cup periodically.
  - d. Probe mixture once with tongue depressor every 30 seconds, starting two minutes prior to minimum specified pot life.
  - e. Pot Life Definition: Time at which a soft stringy mass forms in center of cup.
3. Fabrication of Slant Shear Specimens for Testing bond of Injectable Adhesives to Wet Concrete at 40 Degrees F
- a. Scope: Test method for preparation of diagonal concrete mortar blocks used in determining slant shear strength of low viscosity injectable adhesives in accordance with AASHTO T237 when concrete is wet.
  - b. Materials
    - 1) Diagonal concrete mortar blocks prepared in accordance with AASHTO Test Method T237 and cured to produce a mortar with compressive strength of 5,000 psi or greater.
    - 2) Paraffin wax.
    - 3) Masking Tape: 3/4 inch wide.
    - 4) Suitable 20 mil thick shim stock.
  - c. Preparation
    - 1) Place a 20 mil shim between diagonal faces of two blocks and align so ends and sides are square.
    - 2) Bind block with masking tape covering gap between blocks.
    - 3) Leave a gap between blocks on one face uncovered for removal of shim and application of adhesive.
    - 4) Paint melted paraffin wax over masking tape.
    - 5) Shallow dam may be built up around opening using paraffin wax or modeling clay to help retain adhesive.
    - 6) Apply suitable capping compound to each end of specimen producing smooth surfaces perpendicular to longitudinal axis of block.
    - 7) Remove shim stock from gap opening.

- 8) Soak specimen in water at 40 degrees F, plus or minus three degrees F for at least 24 hours.
- 9) After soaking, remove specimen, shake free water from surface and gap opening.
- 10) Prepare liquid adhesive.
- 11) Within 5 minutes after removing specimen from water, start flowing adhesive into crack without entrapped air bubbles.
- 12) Place specimen in 40 degrees F, plus or minus three degrees F ambient for curing within 15 minutes after removing specimen from water for bonding. Do not expose specimen to temperatures beyond 77 degrees F during the 15 minute period.
- 13) Cure specimen for 72 hours, plus or minus four hours at 40 degrees F, plus or minus three degrees F.

**PART 3 – EXECUTION****3.01 GENERAL**

- A. Finishing: Use as recommended by the manufacturer and as approved by the OWNER'S REPRESENTATIVE to treat the surface of repairs to produce the desired appearance.
- B. Patching: Use as recommended by the manufacturer and as approved by the OWNER'S REPRESENTATIVE to repair non-structural defects in concrete surfaces.
- C. Structural Repair: Use as recommended by the manufacturer and as approved by the OWNER'S REPRESENTATIVE to repair structural defects in concrete surfaces.
- D. Crack Repair:
  1. Use as recommended by manufacturer and as approved by the OWNER'S REPRESENTATIVE to repair dry cracks (non water producing cracks) greater than 0.015 inches in concrete structures.
  2. Repair leaking cracks (water producing cracks) per the manufacturer's recommendations for the approved crack repair product.
  3. The OWNER'S REPRESENTATIVE will conduct a crack survey and classify cracks based upon width and length. The results of the survey will be submitted for execution of the WORK.

**3.02 PREPARATION****A. Finishing**

1. Area to be repaired must be clean, structurally sound, and free of all loose, dirty, oily and scaly material or any material that may affect proper bonding.

**B. Patching & Structural Repair**

1. Perform surface preparation in accordance with repair mortar manufacturer's instructions.
2. Square cut or undercut the perimeter of the area being patched to a minimum depth as recommended by the manufacturer to prevent feathered edges. Do not cut reinforcement.
3. Chip unsound concrete within the patching area to whatever additional depth is necessary to reach sound concrete.
4. Clean roughened surface in accordance with repair mortar manufacturer's instructions.
5. Repair area should be saturated surface dry (SSD) prior to installation of patching material.
6. If reinforcing steel is encountered perform measures to protect from future corrosion as recommended by repair mortar manufacturer.

**C. Crack Repair**

1. Free cracks from loose matter, dirt, laitance, oil, grease, salt and other contaminants.
2. Clean cracks in accordance with epoxy adhesive manufacturer's instructions.
3. Clean surfaces adjacent to cracks from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system.
4. Do not use acids and corrosives for cleaning, unless neutralized prior to injecting epoxy.

**3.03 INSTALLATION****A. Finishing.**

1. Apply scrub coat as recommended by the manufacturer.
2. Trowel apply mortar to scrub coat and finish to match adjacent surfaces.
3. Conduct curing in accordance with manufacturers recommendations.

## B. Patching

1. Scrub a thin layer of repair mortar into the properly prepared surface as a bond coat.
2. Firmly apply the repair mortar to the bond coat as recommended by the manufacturer for the particular installation. Refer to manufacturers instructions for maximum application thickness.
3. Finish repair mortar by hand and to match adjacent surfaces.
4. Conduct curing in accordance with manufacturers recommendations.

## C. Structural Repair

1. Structural repair mortar may be applied using low-pressure spray equipment or by hand.
2. Follow manufacturer's recommendations for application thickness.
3. Finish repair mortar by hand and to match adjacent surfaces.
4. Conduct curing in accordance with manufacturers recommendations.

## D. Crack Repair

1. Sealing: Apply surface seal in accordance with manufacturer's instruction to designated crack face prior to injection. Seal surface of crack to prevent escape of injection epoxy.
2. Entry Ports
  - a) Establish openings for epoxy entry in surface seal along crack.
  - b) Determine space between entry ports equal to thickness of concrete member to allow epoxy to penetrate to the full thickness of the wall.
  - c) Provide a means to prevent concrete dust and fines from contaminating the crack or ports when drilling.
  - d) Space entry ports closer together to allow adjustment of injection pressure to obtain minimum loss of epoxy to soil at locations where:
    - 1) Cracks extend entirely through wall.
    - 2) Backfill of walls on one side.

- 3) Difficult to excavate behind wall to seal both crack surfaces.
  - e) Core drill to verify epoxy depth where only one side of wall is exposed.
3. Epoxy Injection
- a) Store epoxy at minimum of 70 degrees F.
  - b) Start injection into each crack at lowest elevation entry port.
  - c) Continue injection at first port until adhesive begins to flow out of port at next highest elevation.
  - d) Plug first port and start injection at second port until adhesive flows from next port.
  - e) Inject entire crack with same sequence.
4. Finishing
- a) Cure epoxy adhesive after cracks have been completely filled to allow surface seal removal without draining or runback of epoxy material from cracks.
  - b) Remove surface seal from cured injection adhesive.
  - c) Finish crack face flush with adjacent concrete.
  - d) Indentation or protrusions caused by placement of entry ports are not acceptable.
  - e) Remove surface seal material and injection adhesive runs and spills from concrete surfaces.

**3.04 MANUFACTURER'S SERVICES**

- A. Structural Repair: Provide repair mortar system manufacturer's representative at site for installation assistance, inspection and certification of proper installation, and training of applicators.
- B. Crack Repair: Provide crack repair system manufacturer's representative at site for installation assistance, inspection and certification of proper installation, and training of epoxy injection applicators.

**3.05 FIELD QUALITY CONTROL**

- A. Structural Repair: Document and maintain complete accurate records of spray equipment pressure checks.

## B. Crack Repair

## 1. Epoxy Adhesive Two Component Ratio Tests

- a. Disconnect mixing head and pump two adhesive components simultaneously through ratio check device.
- b. Adjust discharge pressure to 160 psi for both adhesive components.
- c. Simultaneously discharge both adhesive components into separate calibrated containers.
- d. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.
- e. Run ratio test for each injection unit at beginning and end of each injection workday, and when injection work is stopped more than 1-hour.
- f. Document and maintain complete accurate records of ratios and pressure checks.

## 2. Injection Pressure Test

- a. Disconnect mixing head of injection equipment and connect two adhesive component delivery lines to pressure check device.
- b. Pressure check Device
  - 1) Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
  - 2) Pressure gauge capable of sensing pressure buildup behind each valve.
- c. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 psi.
- d. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 psi within three minutes.
- e. Run Pressure Test for Each Injection Equipment Unit
  - 1) Beginning and end of each injection workday.
  - 2) When injection work is stopped for more than 45 minutes.
- f. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

3. Crack Injection Tests
  - a. Initial Cores
    - 1) Four inch diameter for full crack depth taken from OWNER'S REPRESENTATIVE selected locations.
    - 2) Take three cores in first 100 linear feet of crack repaired and on core sample for each 500 linear feet thereafter.
  - b. Provide suitable containers for storage, curing, and transportation of test specimens.
  - c. Methods of Testing Cores
    - 1) Penetration: Visual examination.
    - 2) Bond Strength/Compression Test: ASTM C39
  - d. Test Requirements
    - 1) Penetration: Minimum of 90 percent of crack full of epoxy adhesive.
    - 2) Bond Strength/Compression Test: Concrete failure before adhesive failure, or 6,500 psi with no failure of either concrete or adhesive.
  - e. Evaluation and Acceptance of Tests
    - 1) If initial cores pass tests as specified, epoxy adhesive injection WORK at area represented by cores will be accepted.
    - 2) If initial cores fail either by lack of penetration or bond strength, crack repair WORK shall not proceed further until areas represented by cores are reinjected or repaired and retested for acceptance.
    - 3) Obtain verifying core samples, number and location as selected by OWNER'S REPRESENTATIVE, after rework of areas represented by failed initial cores is complete.

f. Core Hole Repair

- 1) Correct WORK as result of testing upon notification from OWNER'S REPRESENTATIVE.
- 2) Refill initial and verifying core holes with an epoxy grout tamped and rodded in-place to form a dense fill.
- 3) Finish surface to blend with adjacent concrete.

**3.06 PROTECTION**

- A. Protect adjacent surfaces, and equipment, from being damaged by the WORK of this Section.

**3.07 CLEANING**

- A. Remove waste materials, unsound material from concrete surfaces, material chipped from walls, and water and other materials used in preparation of application and finishing from the WORK.

**END OF SECTION**