

SECTION 03 11 00
CONCRETE FORMING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. CONTRACTOR shall supply all labor, tools, equipment and materials to set forms for the proper placement of concrete for structures. It is CONTRACTOR's responsibility to design and build adequate forms and to leave them in place until the forms can be safely removed. CONTRACTOR is responsible for damage and injury caused by removing forms carelessly or before the concrete has gained sufficient strength. Means and methods of repair shall be reviewed by ENGINEER prior to performing the WORK.

1.02 RELATED SECTIONS

- A. The following is a list of SPECIFICATIONS which may be related to this section:
1. Section 03 15 00, Construction Joints.
 2. Section 03 31 00, Structural Concrete.
 3. Section 03 35 00, Concrete Finishing.
 4. Section 03 60 00, Grouting.

1.03 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Concrete Institute (ACI):
 - a. Manual of Concrete Practice.
 - b. 117, Specifications for Tolerances for Concrete Construction and Materials.
 - c. 318, Building Code Requirements for Structural Concrete.
 - d. SP-4, Formwork for Concrete.
 2. American Plywood Association (APA):
 - a. J20, Grades and Specifications.
 - b. PS-1-07, US Product Standard for Structural Plywood.
 - c. V345, Concrete Forming.

1.04 SUBMITTALS

- A. General:

1. Design, placement and maintenance of formwork and form systems is the responsibility of CONTRACTOR. Submittals other than those listed are not required nor will they be reviewed.
2. Alternate form system configurations require preparation by a licensed Professional Engineer and submittal to ENGINEER for review and approval.

B. Product Technical Data:

1. Manufacturer and type of form materials.
2. Manufacturer and type of form ties.
3. Manufacturer and type of void form including compressive strength.
4. Manufacturer of form release agent.

- C. CONTRACTOR shall submit information about the type of wedge anchor or nail, and the means of patching the surface for review and acceptance by ENGINEER.

1.05 QUALITY ASSURANCE

- A. Formwork, and if required shoring and reshoring, shall be designed by a Professional Engineer licensed to practice in the state where the PROJECT is located.

PART 2 PRODUCTS

2.01 GENERAL

- A. For the purposes of this SPECIFICATION, exposure shall be defined as a surface, interior or exterior, of a structure that will be exposed to view during its use. For example, the interior wall of a buried culvert is a surface exposed to view.

2.02 FORMS FOR SURFACES EXPOSED TO VIEW

A. Walls:

1. APA PS 1-07, B-B Plyform Class I, exterior. The plywood shall be mill oiled and edge sealed.
2. Symons hand set steel-ply forms, or equal.

B. Beams:

1. APA PS 1-07, B-B Plyform Class I, exterior. The plywood shall be mill oiled and edge sealed.
2. Symons hand set steel-ply forms, or equal.

C. Sides of Column Footings:

1. APA PS 1-07, B-B Plyform Class I, exterior. The plywood shall be mill oiled and edge sealed.

2. Steel of sufficient thickness that the form remains true to shape after numerous repetitive uses.
3. Symons hand set steel-ply forms, or equal.

D. Sides of Curved or Straight Continuous Wall Footings:

1. APA high-density overlay Plyform Class I exterior.
2. APA PS 1-07, B-B Plyform Class I, exterior.
3. For curved surfaces, plywood of sufficient thickness, free from knots and other imperfections, which can be cut and bent and held in place accurately to the required curvature without splintering or splitting, shall be used.

E. Floor and Roof Slabs: APA PS 1-07, B-B Plyform Class I, exterior. The plywood shall be mill oiled and edge sealed.

F. Columns: Regardless of materials of construction, the forms shall be such to permit bracing in two directions at half height and full height at a minimum. Two braces at ninety degrees (90°) are required at half and full height.

1. Steel of sufficient thickness that the form remains true to shape after numerous repetitive uses.
2. Fiberglass of sufficient thickness that the form remains true to shape.

G. Column Capitals: Steel, sixteen (16) gage or thicker, so that the form remains true to shape after numerous repetitive uses.

2.03 FORMS FOR SURFACES NOT EXPOSED TO VIEW

- A. Wood or steel sufficiently tight to prevent mortar leakage.

2.04 ANCHORAGE IN SLABS FOR BRACES FOR WALL AND COLUMN FORMS

- A. Braces shall be anchored to deadmen of sufficient size and weight to maintain the proper wall/column alignment under all load conditions including wind.
- B. Wedge anchors of any type, inserts or concrete nails are specifically not permitted for anchorage of wall or column braces in water retaining structures. Wedge anchors or nails may be used in other structures when in the opinion of ENGINEER the resulting concrete finish patch will be acceptable.

2.05 ANCHORAGE IN SLABS FOR UPTURNED COLUMN FOOTING FORMS

- A. Braces shall be anchored to deadmen of sufficient size and weight to maintain the proper wall/column configuration and diameter. Wedge anchors of any type, inserts or concrete nails are specifically not permitted for anchorage of column footing forms.

2.06 FORM TIES

- A. Water Retaining Structures and Below Grade Structures: Symons, S-Panel Ties, or equal, with water seal and one (1) inch break back cones on both tie ends, shall be used on all wall forms.
- B. Other Structures: Symons, S-Panel Ties, or equal, with one (1) inch break back cones on both tie ends, unless otherwise called out or shown in the DRAWINGS or approved by ENGINEER, shall be used on all wall forms.
- C. Twisted Wire Ties: Twisted wire ties with loops to hold forms in position are not permitted.

2.07 CHAMFER STRIP

- A. Chamfer strips, three-quarters (3/4) inch or as shown on the DRAWINGS, shall be placed in the corners of forms and at the tops of walls or up-turned footings, to produce beveled edges on permanently exposed concrete surfaces. Interior angles of intersecting concrete surfaces and edges of construction joints shall not be beveled unless otherwise indicated in the DRAWINGS. The chamfer strip may be made of wood or polyvinyl chloride (PVC).

2.08 STIFF-BACKS

- A. Stiff-backs for wall forms shall be constructed of lumber or Glulams, uniform in width and thickness, free from knots and other surface defects. Only one (1) joint is permitted in the board of a stiff-back and joints shall be offset so as to not occur at the same point. Stiff-backs shall extend to a point not less than six (6) inches above the top of forms.

2.09 GANG WHALER PLATES FOR THE TOP OF CURVED WALLS

- A. Gang whaler plates shall be constructed of plywood as described below cut to the radius of the wall curve. The gang whaler plate shall be of sufficient depth to permit notching for stiff-backs.
 1. APA high-density overlay Plyform Class I, exterior.
 2. APA PS1, B-B Plyform Class I, exterior.

2.10 WEDGE INSERTS

- A. When permitted by ENGINEER at the tops of walls or columns, wedge inserts may be used to support future formwork or catwalks. The inserts shall be Richmond Screw Anchor, or equal.

2.11 FORM RELEASE AGENT

- A. Magic Kote by Symons Corp. or equal.

PART 3 EXECUTION

3.01 GENERAL

- A. Forms shall be used, wherever necessary, to confine the concrete and shape it to the specified lines and grades as shown on the DRAWINGS. CONTRACTOR shall set and maintain concrete forms so as to ensure completed WORK is within all applicable tolerance limits. If a type of form does not, in the opinion of ENGINEER, consistently perform in an acceptable manner, the type of form shall be changed and the method of erection shall be modified by CONTRACTOR, subject to the review of ENGINEER.
- B. Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of concrete, and shall be maintained rigidly in position. The design of formwork and placing rate of concrete with medium and high-range water reducing agents shall be adjusted to compensate for the greater hydraulic pressures exerted on the forms by concrete of high fluidity.
- C. Forms shall be clean and free from mortar and other foreign material from previous use prior to being placed.
- D. CONTRACTOR shall demonstrate that forms are vertical, with proper alignment, grade or radius when requested by ENGINEER.

3.02 FORM SURFACE TREATMENT

- A. Prior to placing reinforcing steel, coat the forms with a non-staining release agent that will effectively prevent the absorption of moisture and prevent bond of the concrete to the form. Contact with hardened concrete against which fresh concrete is to be placed is prohibited. All bond breaking materials or processes shall be used only after acceptance by ENGINEER. Care shall be taken in applying form oil to avoid contact with reinforcement steel. Embedded material which becomes coated with form oil shall be thoroughly cleaned or replaced at the expense of CONTRACTOR.

3.03 TOLERANCES

- A. Tolerances are defined as allowable variations from specified alignments, grades, and dimensions. Allowable variations from specified alignments, grades, and dimensions are prescribed in the following sub-section. Descriptions of these criteria can be found in Part 2 of the ACI Manual of Concrete Practice, and ACI 117.
- B. Footings and Foundations:
 - 1. Drilled Piers:
 - a. Vertical Alignment: Less than or equal to two percent ($\leq 2\%$) of the shaft length.
 - b. Lateral Alignment: Less than or equal to one-twenty-fourth ($\leq 1/24$) of shaft diameter, three (3) inches maximum.

- c. Level Alignment to Cut-off Elevation: More than one (1) inch, less than three (3) inches.
- 2. Continuous Wall Footings (Circular and Non-circular):
 - a. Lateral Alignment: Less than or equal to two percent ($\leq 2\%$) of the footing width, two (2) inches maximum.
 - b. Relative Alignment: Variation less than or equal to one (≤ 1) inch in ten (10) feet (variation between specified plane and as built surface).
 - c. Cross-sectional Dimension:
 - 1) Horizontal Dimension: Variation more than two (2) inches, less than one-half ($1/2$) inch.
 - 2) Vertical Dimension (thickness): Variation plus or minus one-half ($\pm 1/2$) inch.
 - d. Circular Wall Footing Only:
 - 1) Variation in Radius in Any Twenty (20) Feet of Wall Length: Less than or equal to one-half ($\leq 1/2$) inch.
 - 2) Variation in Radius in Entire Wall Length: Less than or equal to one (≤ 1) inch.
- 3. Column Footings:
 - a. Lateral Alignment: Variation less than or equal to two (≤ 2) inches.
 - b. Level Alignment: Variation from specified elevation more than one-half ($1/2$) inch, less than two (2) inches.
 - c. Relative Alignment: Variation less than or equal to one (≤ 1) inch in ten (10) feet (variation between specified plane and as built surface).
 - d. Cross-sectional Dimension:
 - 1) Horizontal Dimension: Variation more than two (2) inches, less than one-half ($1/2$) inch.
 - 2) Vertical Dimension (Thickness): Variation plus or minus one-half ($\pm 1/2$) inch.
- C. Cast-in-Place Concrete for Buildings and other Structures:
 - 1. Member (such as a beam, column, wall, slab, or pier):
 - a. Vertical Alignment: Variation from specified plump less than or equal to three-eighths ($\leq 3/8$) inch (full height) one-quarter ($1/4$) inch (one form section).

b. Lateral Alignment:

- 1) Maximum in Any Bay: Variation less than or equal to one-half ($\leq 1/2$) inch.
- 2) Maximum in Any Twenty (20) Feet of Length: Variation less than or equal to one-half ($\leq 1/2$) inch.
- 3) Maximum for Entire Wall Length: Variation less than or equal to one (≤ 1) inch.
- 4) Floor and Wall Opening Locations: Variation less than or equal to one-half ($\leq 1/2$) inch.
- 5) Saw cuts and Joints: Variation less than or equal to three-quarters ($\leq 3/4$) inch.

c. Level Alignment:

- 1) Top Elevation of Slabs: Variation less than or equal to three-quarters ($\leq 3/4$) inch.
- 2) Lintels, Other Lines Exposed to View: Variation less than or equal to three-quarters ($\leq 3/4$) inch.

d. Cross-sectional Dimensions:

- 1) Walls and Slabs (Thickness): Variation plus or minus one-quarter ($\pm 1/4$) inch.
- 2) Columns and Beams: Variation more than one-half ($1/2$) inch, less than one-quarter ($1/4$) inch.
- 3) Size of Wall and Floor Openings: Variation plus or minus one-quarter ($\pm 1/4$) inch.

e. Relative Alignment (Offset between Adjacent Formwork): Variation plus or minus one-quarter inch ($\pm 1/4$) inch.

f. Variation in Specified Grade:

- 1) For Any Distance Less than Ten (< 10) Feet: Variation less than or equal to one-quarter ($\leq 1/4$) inch.
- 2) For Entire Structure: Variation plus or minus one-half ($\pm 1/2$) inch.
- 3) For Manholes and Outlet Structures: Variation less than or equal to one (≤ 1) inch.

2. Stairways:

a. Relative Alignment:

- 1) Difference in Height between Adjacent Risers: One-eighth ($1/8$) inch.
- 2) Difference in Width between Adjacent Treads: One-quarter ($1/4$) inch.

3.04 PLUMB AND STRING LINES

- A. Plumb and string lines shall be installed on wall and column forms before, and maintained during, concrete placement. There shall be sufficient number of plumb or string lines in walls, for example at every other stiff-back, properly installed to permit

continuous monitoring. During concrete placement, CONTRACTOR shall continually monitor plumb and string line positions and immediately correct deficiencies. The plumb and string lines shall extend to a point at least six (6) inches above the top of wall or column.

3.05 FORMWORK CAMBER

- A. In order to maintain specified tolerances of joists, beams or slabs subject to dead load deflection, CONTRACTOR shall camber formwork to compensate for dead load deflection prior to hardening of the concrete.

3.06 GANG WHALER PLATES FOR CIRCULAR WALLS

- A. CONTRACTOR shall place a gang whaler plate cut to the curvature of the wall, such as a circular wall, at the top of the wall forms. The gang whaler plate shall be attached to the forms with a gang whaler rod at appropriately designed intervals. The gang whaler plate may be notched to permit the stiff-back to extend above the top of the wall forms. The gang whaler plate shall be sufficiently stiff to maintain the required curvature.

3.07 HAND SET MODULAR FORMS

- A. Hand set modular forms, such as Symons hand set steel-ply forms, shall be placed with no more than two intersecting joints occurring at one level in the formwork above the bottom modular form level. Figure 1 illustrates the required form pattern.

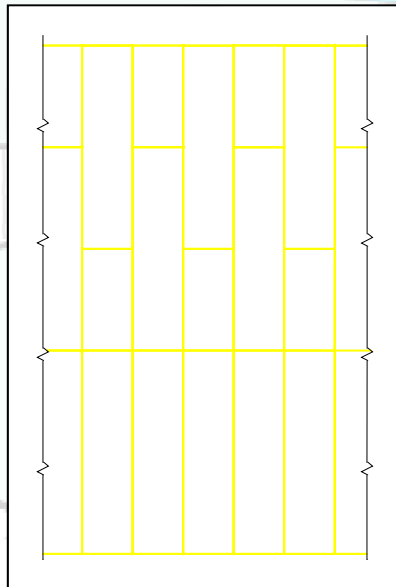


Figure 1

- B. The above form configuration is one way recommended by Simons Corp. to eliminate vertical, in plane, bending of the forming system. CONTRACTOR may develop alternate means of maintaining vertical alignment.

3.08 FORMWORK CLOSURE

- A. Forms that prohibit visual review of items such as reinforcing steel, waterstops and bearing pads by ENGINEER, shall not be placed until ENGINEER has performed a final review of the reinforcing steel.
- B. CONTRACTOR shall use compressed air from an air compressor to blow out construction debris and dirt at the bottom of sections or members to be placed such as walls, slabs, beams and columns, prior to placing forms or concrete.
- C. CONTRACTOR shall demonstrate to ENGINEER that all debris, such as loose concrete particles, saw dust, loose tie wire, bar tags, tape, trash and dirt, have been thoroughly removed.

3.09 HOT OR COLD WEATHER PLACEMENT AND STEEL FORMS

- A. Prior to placing concrete when steel forms are used, the forms shall be heated when the surface temperature of the form is below forty degrees Fahrenheit (40°F) or cooled when the surface temperature of the form is above ninety degrees Fahrenheit (90°F). If water is used to cool forms where ponding of water may occur (for example, at the bottom of a column), the water shall be permitted to drain prior to placing concrete.

3.10 REMOVAL OF FORMS

- A. The forms for any portion of a structure shall not be removed until the concrete has reach sufficient strength with a factor of safety of 2.0, to withstand applied loads such as self weight and wind loads or withstand damage when the forms are removed.
- B. For post-tensioned concrete slabs and beams, formwork shall not be removed until the entire slab or member has been stressed and stressing records accepted.

3.11 RESHORES

- A. When a reshore plan is to be performed, it shall comply with Article Quality Assurance.

END OF SECTION

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SECTION 03 15 00

CONSTRUCTION JOINTS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. CONTRACTOR shall supply all labor, tools, equipment and material for the preparation of construction joints in concrete in accordance with these SPECIFICATIONS and as shown in the DRAWINGS.

1.02 RELATED SECTIONS

- A. The following is a list of SPECIFICATIONS which may be related to this section:
 1. Section 03 11 00, Concrete Forming.
 2. Section 03 15 13, Waterstops.
 3. Section 03 21 00, Reinforcing Steel.
 4. Section 03 31 00, Structural Concrete.
 5. Section 03 60 00, Grouting.
 6. Section 32 16 00, Sidewalks, Curbs, and Gutters.

1.03 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 1. American Concrete Institute (ACI):
 - a. 117, Specifications for Tolerances for Concrete Construction and Materials.
 - b. 301, Specifications for Structural Concrete.
 - c. 302, Guide for Concrete Floor and Slab Construction.
 - d. 318, Building Code Requirements for Structural Concrete.
 2. ASTM International (ASTM): C1059, Standard Specification for Latex Agents for Bonding Fresh To Hardened Concrete.

1.04 SUBMITTALS

- A. Provide Product Data for the Following: Bonding Agent.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Epoxy Bonding Agent:
 - 1. Master Builders; Concessive Liquid (LPL).
 - 2. Master Builders; Concessive Standard Liquid.
- B. Concrete and Closure Grout Placement: In accordance with Section 03 60 00, Grouting.

PART 3 EXECUTION

3.01 EXAMINATION

- A. ENGINEER shall review the preparation of all construction joints prior to concrete and grout closure placements. It is the responsibility of CONTRACTOR to notify ENGINEER of these activities. If joint placement is performed without ENGINEER's presence or approval, the WORK may be deemed unacceptable and non-conforming to these SPECIFICATIONS. If ENGINEER determines that construction review of a particular activity is unnecessary, ENGINEER will provide direction to CONTRACTOR to proceed with that particular activity without construction review.

3.02 SURFACE PREPARATION

- A. The surface of concrete construction joints shall be clean of all materials that inhibit bond. Materials such as curing compounds, laitance, saw dust, wood, dirt, polyethylene, pipe tape coating, and paper shall be removed. Concrete shall be roughened to produce a surface texture of plus or minus one-sixteenth ($\pm 1/16$) inch. Concrete surfaces shall be wetted with clean potable water and standing water removed immediately before new concrete or closure grout is placed. Unless otherwise called out in the DRAWINGS, a bonding agent shall be used prior to placing the concrete or grout.

3.03 PIPE GROUT CLOSURE SECTIONS

- A. Pipe Surface Preparation: Unless otherwise detailed in DRAWINGS, all pipes penetrating concrete sections such as wall and floor slabs shall have all coatings and other materials that can inhibit bond completely removed from the portion of the pipe to be in contact with the concrete or slab closure grout.
- B. Ground Surface Preparation: The ground surface at joints such as pipe/slab closures shall be smooth and properly graded and compacted. All debris such as Styrofoam, paper, polyethylene and wood shall be removed. The ground surface shall be dampened and prepared to prevent the inclusion of dirt, pieces of aggregate or balls of soil in the concrete or grout.

3.04 CONCRETE AND CLOSURE GROUT PLACEMENT

- A. Mixing, surface preparation in addition to that prescribed above, placement, and curing of grout at pipe closure joints shall be performed in strict accordance with Section 03 60 00, Grouting, and when a proprietary grout is specified, with the grout manufacturer's directions. Special care shall be taken to ensure that the grout is thoroughly and properly consolidated at waterstops, pipe weep rings, and existing concrete surfaces. An appropriate capacity vibrator shall be used when necessary or required by the manufacturer to properly consolidate the grout.

END OF SECTION





SECTION 03 15 13

WATERSTOPS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. CONTRACTOR shall furnish and securely install expanding rubber waterstops where shown or specified in the DRAWINGS. The WORK includes cleaning of concrete surfaces and installation of expanding rubber waterstop.

1.02 RELATED SECTIONS

- A. The following is a list of SPECIFICATIONS which may be related to this section:
 - 1. Section 03 15 00, Construction Joints.
 - 2. Section 03 31 00, Structural Concrete.

1.03 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. ASTM International (ASTM):
 - a. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.
 - b. D2240, Standard Test Method for Rubber Property—Durometer Hardness.

1.04 SUBMITTALS

- A. Provide product data for the following:
 - 1. Waterstop Product.
 - 2. Adhesive.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver the waterstop materials to the PROJECT site in the manufacturer's unpacked containers with all labels intact and legible at time of use. Materials shall be stored in a secure, indoor, dry area. Maintain the waterstops in a dry condition during delivery, storage, handling, installation, and concealment.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Hydrophilic Rubber Waterstop:

1. The waterstop shall have the minimum performance standard of:

Property	ASTM Standard	Results
Tensile Strength (MPa)	D412	0.98
Elongation	D412	550
Hardness (Hs)	D2240	30 Durometer Type A
The time period to maximum volume expansion is 35 days.		

2. Materials approved for use are:

- a. Adeka Corporation; MC-2010M.
- b. Adeka Corporation; KM-3030M.
- c. Adeka Corporation; P201 (except in contact with potable water).
- d. Adeka Corporation; KC Series.

B. Adhesive:

1. The adhesive shall be 3M-2141 as manufactured by the 3M Company, or Adeka Corporation H-1000 Ultra Bond.

PART 3 EXECUTION

3.01 GENERAL

- A. Coordinate as required with other trades and SPECIFICATIONS to ensure proper execution of the waterstop installation.
- B. The components and installation procedures shall be in accordance with the manufacturer's printed specifications and recommendations. Installation shall be performed by skilled workers who are trained in procedures and methods required for proper performance of the waterstop.

3.02 EXAMINATION

- A. Examine the concrete surface and correct any surface imperfections which may prevent proper installation and performance of the waterstop. The finished concrete surface, prior to surface preparation, shall be equal to a steel trowel finish.

3.03 SURFACE PREPARATION

- A. Concrete surfaces shall be clean and free of dirt, saw dust, laitance, grease, form oils, form release agent, or other contamination to ensure proper adhesion of the waterstop to the concrete surface. Use a wire brush to lightly roughen the surface. Remove all concrete dust with a soft brush.

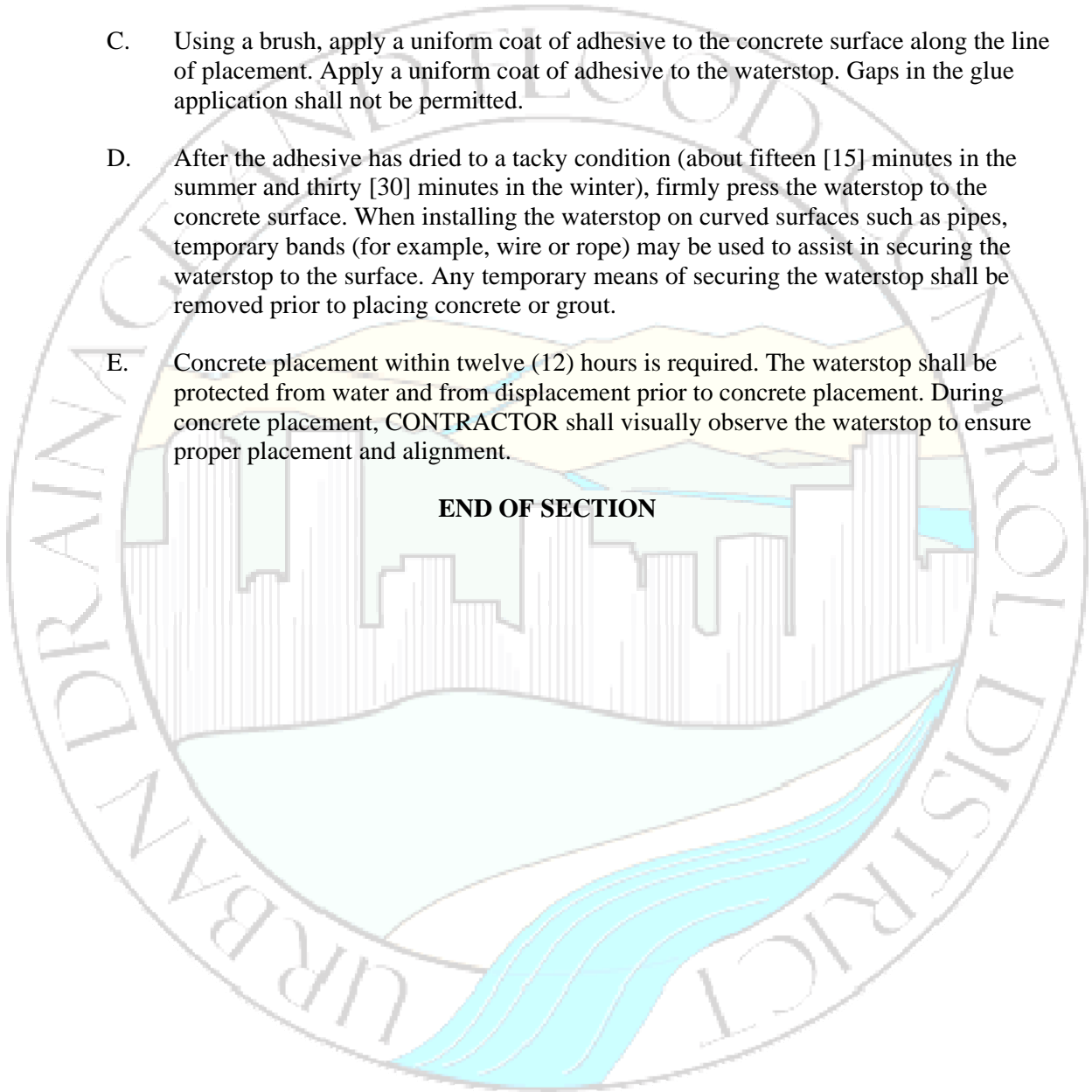
3.04 WATERSTOP PLACEMENT

- A. Measure and cut an exact length of waterstop. Splices are not permitted in the waterstop in vertical wall joints of structures. Splices in horizontal joints are

acceptable, however, only one (1) splice is permitted in twenty five (25) feet. Splice of waterstops in horizontal joints shall be made by butting and gluing the ends of the waterstop with an approved adhesive.

- B. Refer to the manufacturer's recommendations for minimum clearance to a concrete face. Unless a greater clearance is recommended by the manufacturer, the minimum clearance shall be two (2) inches. Use the greater clearance if the recommended clearance is more than two (2) inches.
- C. Using a brush, apply a uniform coat of adhesive to the concrete surface along the line of placement. Apply a uniform coat of adhesive to the waterstop. Gaps in the glue application shall not be permitted.
- D. After the adhesive has dried to a tacky condition (about fifteen [15] minutes in the summer and thirty [30] minutes in the winter), firmly press the waterstop to the concrete surface. When installing the waterstop on curved surfaces such as pipes, temporary bands (for example, wire or rope) may be used to assist in securing the waterstop to the surface. Any temporary means of securing the waterstop shall be removed prior to placing concrete or grout.
- E. Concrete placement within twelve (12) hours is required. The waterstop shall be protected from water and from displacement prior to concrete placement. During concrete placement, CONTRACTOR shall visually observe the waterstop to ensure proper placement and alignment.

END OF SECTION





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SECTION 03 21 00

REINFORCING STEEL

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. This WORK shall consist of furnishing and placing reinforcing steel in accordance with these SPECIFICATIONS and in conformity with the DRAWINGS.

1.02 RELATED SECTIONS

- A. The following is a list of SPECIFICATIONS which may be related to this section:
 - 1. Section 03 31 00, Structural Concrete.

1.03 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American Association of State and Highway Transportation Officials (AASHTO):
 - a. M31M/M31, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - b. AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges.
 - 2. American Concrete Institute (ACI):
 - a. ACI Detailing Manual.
 - b. 117, Specifications for Tolerance for Concrete Construction and Materials.
 - c. 318, Building Code Requirements for Structural Concrete.
 - 3. American Welding Society (AWS):
 - a. D1.1/D1.1M, Structural Welding Code - Steel.
 - b. D1.4/D1.4M, Structural Welding Code - Reinforcing Steel.
 - c. D2.0, Welded Highway and Railway Bridges.
 - 4. ASTM International (ASTM):
 - a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
 - b. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.

- c. A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - d. A996/A996M, Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.
 - e. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
 - f. A767/A767M, Standard Specification for Zinc-coated (Galvanized) Steel Bars for Concrete Reinforcement.
 - g. A775/A775M, Standard Specification for Epoxy-coated Steel Reinforcing.
5. Concrete Reinforcing Steel Institute (CRSI):
- a. Manual of Standard Practice.
 - b. Placing Reinforcing Bars.

1.04 SUBMITTALS

- A. Two copies of a list of all reinforcing steel and bending diagrams shall be furnished to the ENGINEER at the site of the work at least one week before the placing of reinforcing steel is begun. Such lists will not be reviewed for accuracy. The CONTRACTOR shall be responsible for the accuracy of the lists and for furnishing and placing all reinforcing steel in accordance with the details shown on the plans.

1.05 DELIVERY, STORAGE, AND PROTECTION

- A. Reinforcing steel shall be stored off of the ground and protected from oil or other materials detrimental to the steel or bonding capability of the reinforcing bar. Epoxy-coated reinforcing bars shall be stored on protective cribbing.

PART 2 PRODUCTS

2.01 REINFORCING STEEL

- A. Deformed Bars: All bar steel reinforcement shall be of the deformed type, ASTM A615, AASHTO M31M/M31, and Grade (40 or 60) as specified on the DRAWINGS.
- B. Spirals:
 - 1. Spirals, hot-rolled plain or deformed bars per ASTM A615, Grade 60 or cold drawn wire per ASTM A82/A82M as specified on the DRAWINGS.
 - 2. Spirals for columns shall have two (2) "spacers" with a section modulus $>0.030\text{in}^3$ in order to maintain the proper pitch and spacing.
- C. Epoxy-Coated Reinforcing Bars: Epoxy-coated reinforcing bars shall conform to ASTM A775/A775M. When required, damaged epoxy coating shall be repaired with

patching material conforming to ASTM A775/A775M in accordance with the material manufacturer's recommendations.

- D. Zinc-coated (Galvanized Reinforcing Bars): Zinc-coated reinforcing bars shall conform to ASTM A767/A767M. When required, damaged zinc coating shall be repaired with a zinc-rich formulation conforming to ASTM A767/A767M.
- E. Welded Wire Fabric: All welded wire fabric reinforcement shall conform to ASTM A497/A497M.
- F. Identification:
 - 1. Bundles of reinforcing bars and wire spirals shall be tagged, with a metal tag, showing specification, grade, size, quantity, and suitable identification to permit checking, sorting, and placing. When bar marks are used to identify reinforcing bars on the DRAWINGS, the bar mark shall be shown on the tag. Tags shall be removed prior to concrete placement.
 - 2. Bundles of flat sheets and rolls of welded wire fabric shall be tagged similar to reinforcing bars.

2.02 TIE WIRE

- A. 16 gauge wire ties, manufactured by American Wire Tie, Inc., or equal. When epoxy-coated reinforcing steel is shown on the DRAWINGS, PVC coated wire ties shall be used. The minimum PVC coating shall be 0.7 mils.

2.03 BAR SUPPORTS

- A. General: Bar supports and spacing shall be in accordance with the CRSI Manual of Standard Practice, Chapter 3, a maximum of four (4) feet, or as required by the DRAWINGS.
- B. Floor Slabs: Uncoated steel or non-metallic composite chairs shall be used unless otherwise shown on the DRAWINGS. If required by ENGINEER, the chair shall be stapled on a bearing pad to prevent chair displacement. The bearing pad shall be made of exterior grade plywood and be approximately five (5) inches square.
- C. Columns: Plastic "space wheels" manufactured by Aztec (Model DO 12/40), or equal, are required.
- D. Epoxy-Coated and Zinc-Coated Bar Supports: Epoxy-coated reinforcing bars supported from formwork shall rest on coated wire bar supports made of dielectric or other acceptable materials. Wire supports shall be fully coated with dielectric material, compatible with concrete. Reinforcing bars used as support bars shall be epoxy-coated. In walls reinforced with epoxy-coated bars, spreader bars shall be epoxy-coated. Proprietary combination bar clips and spreaders used in walls with epoxy-coated reinforcing shall be made of corrosion-resistant material or coated with dielectric material.

2.04 FABRICATION

- A. Fabrication tolerances for straight and bent bars shall be in accordance with the requirements of Subsection 4.3, Tolerance, of ACI 315 and the CRSI Manual of Standard Practice.

PART 3 EXECUTION

3.01 GENERAL

- A. Rust, seams, surface irregularities, or mill scale shall not be cause for rejection provided that the weight and height of deformations of a hand-wire-brushed test specimen are not less than the applicable ASTM Specification.

3.02 BAR LIST

- A. CONTRACTOR shall be responsible for the accuracy of the lists and for furnishing and placing all reinforcing steel in accordance with the details shown on the DRAWINGS.
- B. Bar lists and bending diagrams for structures, which are included on the DRAWINGS, do not have to be furnished by CONTRACTOR. When bar lists and bending diagrams are included on the DRAWINGS, they are intended for estimating approximate quantities. CONTRACTOR shall verify the quantity, size, and shape of the bar reinforcement against those shown on the DRAWINGS and make any necessary corrections before ordering.

3.03 BENDING

- A. All reinforcing bars shall be bent cold. Bars partially embedded in concrete shall not be field bent, except as shown on the DRAWINGS or permitted. Bars shall not be bent or straightened in a manner that may injure the material.

3.04 SPIRALS

- A. One and one-half (1-1/2) finishing bends are required at the top and bottom of the spiral. Spacers shall be provided in accordance with Chapter 5, Section 9 of the CRSI Manual of Standard Practice. Welding as an aid to fabrication and/or installation is not permitted.

3.05 PLACING AND FASTENING

- A. When placed in the WORK, the reinforcing bars shall be free from dirt, loose mill scale, paint, oil, loose rust, or other foreign substance.
- B. The placing, fastening, splicing, and supporting of reinforcing steel and wire mesh or bar mat reinforcement shall be in accordance with the DRAWINGS and the latest edition of "CRSI Placing Reinforcing Bars." In case of discrepancy between the DRAWINGS and the CRSI publication stated above, the DRAWINGS shall govern. Reinforcement shall be placed within the tolerances provided in ACI 117.
- C. Steel reinforcement shall be accurately placed in the positions shown on the DRAWINGS and firmly held during the placing and setting of concrete by means of

spacer strips, stays, metal chairs or other approved devices or supports. Precast concrete bricks or other types of bricks are not permitted for support of reinforcement in footings, slabs, or any other part of the work. Chair and bolster supports for slabs and walls shall be spaced at a maximum of four- (4-) foot centers unless otherwise shown on the DRAWINGS. Staples used to attach bar supports to wall and roof forms shall have the staple “tails” clipped after form removal. For columns, three (3) wheels, spaced one hundred twenty degrees (120°) apart, shall be placed every four (4) feet of column height. CONTRACTOR may increase the column spiral pitch if a conflict occurs with the wheel. Pre-tied column reinforcing steel lowered into column forms shall be lowered vertically to prevent damage to the space wheels.

- D. Bars shall be securely tied at fifty percent (50%) of all intersections except where spacing is less than one (1) foot in each direction, when alternate intersections shall be tied unless otherwise called out on the DRAWINGS or in applicable SPECIFICATIONS. Tying of steel by spot welding shall not be permitted unless specifically authorized by ENGINEER. The placing and securing of the reinforcement in any unit or section shall be accepted by ENGINEER before any concrete is placed in any such unit or section.
- E. Bundle bars shall be tied together at not more than six- (6-) foot centers.

3.06 SPLICING

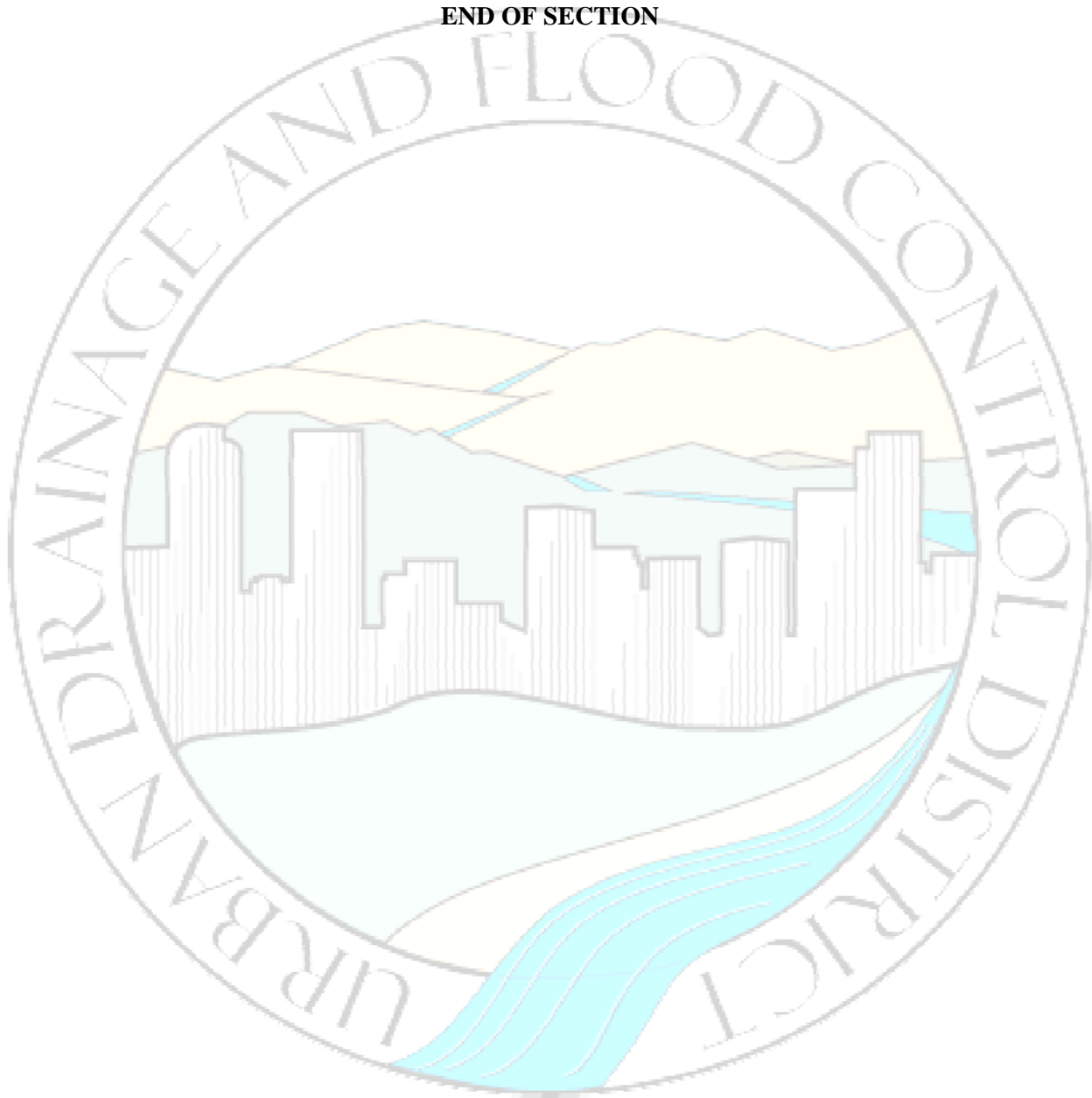
- A. Bar steel reinforcement shall be furnished in the full lengths indicated on the DRAWINGS. Splicing of bars, except where shown on the DRAWINGS, shall not be permitted without the written acceptance of ENGINEER. Splices shall be staggered. In cases where permission is granted to splice bars, other than those shown on the DRAWINGS, the additional material required for the lap shall be furnished by CONTRACTOR at CONTRACTOR’s own expense. The minimum distance between staggered splices for reinforcing bars shall be the length required for a lapped splice in the bar. All splices shall be full contact splices.
- B. Splices shall not be permitted at points where the section is not sufficient to provide a minimum distance of two (2) inches between the splice and the nearest adjacent bar or the surface of the concrete.
- C. Welding of reinforcement shall be done only if detailed on the DRAWINGS or if authorized by ENGINEER in writing. Welding shall be done by a certified welder. The welding shall conform to AWS D1.4/D1.4M with the modifications and additions specified hereinafter. Where AWS D2.0 Specifications for Welded Highway and Railway Bridges is referenced, the reference shall be construed to be for AWS D1.1. Where the term AWS D1.1/D1.1M is used it shall mean the American Welding Society Structural Welding Code, D1.5/D1.5M as modified and amended by the AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges. After completion of welding, coating damage to coated reinforcing steel bars shall be repaired.
- D. When required or permitted, a mechanical connection may be used to splice reinforcing steel bars or as substitution for dowel bars. The mechanical connection shall be capable of developing a minimum of one hundred twenty five percent (125%) of the yield strength of the reinforcing bar in both tension and compression. All parts of mechanical connections used on coated bars, including steel splice

sleeves, bolts, and nuts shall be coated with the same material used for repair of coating damage.

3.07 CUTTING

- A. When coated reinforcing bars are cut in the field, the ends of the bars shall be coated with the same material used for repair of coating damage.

END OF SECTION



SECTION 03 31 00

STRUCTURAL CONCRETE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. CONTRACTOR shall furnish all labor, tools, and equipment for the construction of reinforced cast-in-place concrete.
- B. This section includes basic finishing and curing methods, accessory control, and expansion and contraction joint devices.

1.02 RELATED SECTIONS

- A. The following is a list of SPECIFICATIONS which may be related to this section:
 - 1. Section 03 11 00, Concrete Forming.
 - 2. Section 03 15 00, Construction Joints.
 - 3. Section 03 15 13, Waterstops.
 - 4. Section 03 21 00, Reinforcing Steel.
 - 5. Section 03 35 00, Concrete Finishing.
 - 6. Section 03 39 00, Concrete Curing.
 - 7. Section 07 92 00, Sealants.
 - 8. Section 32 16 00, Sidewalks, Curbs, and Gutters.

1.03 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. ASTM International (ASTM):
 - a. C33, Standard Specification for Concrete Aggregates.
 - b. C94/C94M, Standard Specification for Ready-Mixed Concrete.
 - c. C150, Standard Specification for Portland cement.
 - d. C260, Standard Specification for Air-entraining Admixtures for Concrete.
 - e. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.

- f. C618, Standard Specification for Coal and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - g. C979, Standard Specification for Pigments for Integrally Colored Concrete.
 - h. C1059, Standard Specification for Latex Agents for Bonding Fresh To Hardened Concrete.
 - i. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
2. American Concrete Institute (ACI):
- a. 211, Standard Practice for Selecting Proportions for Concrete.
 - b. 301, Specifications for Structural Concrete.
 - c. 304, Guide for Measuring, Mixing, Transporting and Placing Concrete.
 - d. 305.1, Specification for Hot Weather Concreting.
 - e. 306.1, Specification for Cold Weather Concreting.
 - f. 309, Standard Practice for Consolidating Concrete.
 - g. 318, Building Code Requirements for Structural Concrete.
 - h. 504, Guide to Joint Sealants.

1.04 SUBMITTALS

- A. Provide product data on the following:
- 1. Ready-mixed concrete mix designs.
 - 2. Fly ash.
 - 3. Admixtures (such as air-entraining and water-reducing admixtures).
 - 4. Form release agents.
 - 5. Bonding agents.
 - 6. Grout.

1.05 QUALITY ASSURANCE

- A. Qualifications: The ready-mixed concrete supplier to CONTRACTOR shall have the capability to produce and deliver concrete, meeting the requirements of the DRAWINGS and SPECIFICATIONS. The supplier shall have a contingency plan for a back-up plant in the event of a mechanical malfunction of one of the primary plant(s).

1.06 DELIVERY, STORAGE, AND HANDLING

- A. The ready-mixed concrete truck driver shall provide the batch ticket to ENGINEER at the time of concrete delivery. The ticket shall summarize the following information legibly in an easily discernible table:
1. Weight in pounds of all materials, excepting the water reducing and air-entraining agents which shall be in ounces.
 2. Cubic yards batched.
 3. The ratio of water to cementitious (W/C) materials ratio.
 4. Temperature of the concrete at the time it was batched.
 5. Time of batching.
 6. Free moisture in the fine and coarse aggregates in percent of weight of aggregate.
 7. Gallons of water that may be added at the site without exceeding the permissible W/C ratio.
 8. Concrete Mix Design Number.

PART 2 PRODUCTS

2.01 MATERIALS

- A. General: Acquire cement and aggregate from the same source for all work.
- B. Cement: Cement shall be Portland cement Type II, unless otherwise indicated on the DRAWINGS.
- C. Aggregate:
1. Fine Aggregate: Fine aggregate shall consist of hard, strong, durable particles complying with the provisions of ASTM C33.
 2. Coarse Aggregate: Coarse aggregate shall conform to the provisions of ASTM C33. Aggregate shall be crushed aggregate or angular screened natural aggregate. Hydraulic - cement aggregate is unacceptable.

- D. **Water:** Water shall be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances that may be deleterious to concrete or steel. Mixing water for prestressed, pretensioned and prestressed post-tensioned concrete or for concrete which will contain aluminum embedments shall not contain deleterious amounts of chloride ion.
- E. **Admixtures:** Admixtures to be used in concrete shall be subject to prior acceptance by ENGINEER. The admixture shall maintain the same composition and performance throughout the WORK as the product used in the concrete proportions established in accordance with ACI 211. Admixtures containing chloride ions shall not be used.

1. **Air Entrainment:**

- a. An air-entraining agent shall be used in all concrete. The agent used shall conform to ASTM C260.
- b. Unless otherwise shown on the DRAWINGS, the amount of air-entraining agent used in each concrete mix shall be such as will affect the entrainment of the percentage of air shown in the following tabulation in the concrete as discharged from the mixer or pumper discharge hose if applicable. Table 1 is applicable for concrete strengths less than five thousand (5,000) psi.

Table 1		
Nominal Max. Aggregate Size (Inch)	Average Air Content (Percent)	
	Severe Exposure	Moderate Exposure
3/8	7-1/2 ± 1-1/2	6 ± 1-1/2
3/4	6 ± 1-1/2	5 ± 1-1/2
1-1/2	5-1/2 ± 1-1/2	4-1/2 ± 1-1/2

- c. The level of exposure shall be determined by ENGINEER.
 - d. When a batch of concrete delivered to the PROJECT does not conform to the minimum specified air content, an air-entraining admixture may be added, one (1) time only for the batch, at CONTRACTOR's option prior to consideration for rejection. After the admixture is added, the concrete shall be remixed for a minimum of twenty (20) revolutions of the mixer drum at mixing speed. The concrete shall then be retested and if found acceptable, may be placed in accordance with the SPECIFICATIONS.
2. **Water Reducing, Set-Controlling Admixture:** CONTRACTOR shall use a "mid-range" water reducing, set controlling admixture, Polyheed 997, or equal. The water-reducing admixture shall be used in all concrete and shall conform to ASTM C494/C494M, specifically Types A, B, C, D, and E.

3. Finely Divided Mineral Admixtures (Fly Ash): Mineral admixtures shall be limited to fly ash conforming to ASTM C618, Class C or Class F. Class C fly ash is not permitted where sulfate resistant cement is required.

F. Evaporative Retardant: In accordance with Section 03 29 00, Concrete Curing.

G. Bituminous Coating: Bituminous Coating for aluminum pipes will be in accordance with AASHTO M-190 Type A.

H. Grout: In accordance with Section 03 60 00, Grouting.

I. Epoxy Bonding Agent:

1. Master Builders; Concrese Liquid (LPL).

2. Master Builders; Concrese Standard Liquid.

2.02 COMPRESSIVE STRENGTH

A. Concrete compressive strength requirements consist of a minimum strength that must be obtained before various loads of stresses are applied to the concrete and, for concrete designated by strength, a minimum strength at the age of twenty eight (28) days. Unless otherwise shown on the DRAWINGS, the twenty eight (28) day compressive strength of structural concrete shall be a minimum of four thousand five hundred (4,500) psi.

B. The mix shall be designed for required strengths in accordance with ACI 301. The ratio of water to the sum of concrete plus pozzolan shall not exceed 0.45 by weight for durable, watertight, concrete. The amount of fly ash in the mix shall be between fifteen and twenty percent (15 and 20%) by weight of the total cementitious materials.

C. Unless otherwise permitted or specified in the DRAWINGS, the concrete shall be proportioned and produced to have a slump not to exceed four (4) inches or less than two and one-half (2-1/2) inches. Concrete not consolidated by internal vibration shall be proportioned to have a slump not to exceed five and one-half (5-1/2) inches or less than four (4) inches.

2.03 SOURCE QUALITY CONTROL

A. Batching:

1. Measuring and batching of materials shall be done at a batching plant.

2. Portland Cement:

a. Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete unless the cement is weighed. Bulk cement shall be weighed on scales separate and distinct from the aggregate hopper or hoppers. Batching shall be such that the accuracy of batching shall be plus or minus one percent of the required weight.

3. Water:

- a. Unless water is to be weighed, the water-measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. In lieu of the volume method, CONTRACTOR shall be permitted to use a water-metering device.

4. Aggregates:

- a. Aggregates shall be handled from stockpiles or other sources to the batching plant in such a manner as to secure a uniform grading of the material. Aggregates that have become segregated, or mixed with earth or foreign material, shall not be used. Batching shall be so conducted as to result in the weights of material required for each type aggregate within a tolerance of two percent (2%).
- b. Free water contents of the coarse and fine aggregates shall be continuously tested and concrete mixture adjusted for moisture conditions of the aggregate in order to meet the designated water/cement ratio.

5. Fine Aggregate:

- a. The proportion of fine aggregate shall be between thirty six and forty four percent (36 and 44%) by volume of the total aggregates in the concrete.

B. Mixing:

1. Ready-mixed concrete shall be either “central mixed” or “shrink mixed” concrete as defined in ASTM C94/C94M. “Truck mixed” concrete as defined in ASTM C94/C94M shall not be permitted. Mixing time shall be measured from the time water is added to the mix, or cement contacts the aggregate. All concrete shall be homogeneous and thoroughly mixed, and there shall be no lumps or evidence of undispersed cement. Mixers and agitators, which have an accumulation of hard concrete or mortar, shall not be used. Ready-mixed concrete shall be mixed and transported in accordance with ASTM C94/C94M.
2. The temperature of mixed concrete, immediately before placing shall not be less than fifty degrees Fahrenheit (50°F) or more than ninety degrees Fahrenheit (90°F). Aggregates and water shall be heated or cooled as necessary to produce concrete within these temperature limits. Neither aggregates nor mixing water shall be heated to exceed one hundred fifty degrees Fahrenheit (150°F).
3. The time elapsing from the time water is added to the mix (or the cement comes in contact with aggregate) until the concrete is deposited in place at the site of the WORK shall not exceed sixty (60) minutes when the concrete is hauled in non-agitating trucks, nor more than ninety (90) minutes when hauled in truck mixers or truck agitators.

4. The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first one-quarter (1/4) of the specified mixing time.
5. Cement shall be charged into the mixer by means that will not result in loss of cement because of the effect of wind, or in accumulation of cement on surfaces of hoppers or in other conditions which reduce or vary the required quantity of cement in the concrete mixture.

C. Transporting Mixed Concrete; Mixed Concrete or Truck Mixers:

1. Transporting of mixed concrete shall conform to ASTM C94/C94M.
2. Truck agitators shall be loaded not to exceed the manufacturer's guaranteed capacity. They shall maintain the mixed concrete in a thoroughly mixed and uniform mass during hauling.
3. No additional mixing water shall be incorporated into the concrete during hauling or after arrival at the delivery point, unless approved by ENGINEER. If additional water is to be incorporated into the concrete at the site, the drum shall be revolved not less than thirty (30) revolutions at mixing speed after the water is added and before discharge is commenced. One (1) addition of water at the site to adjust mix workability is permitted but the maximum water cement ratio shall not be exceeded.
4. CONTRACTOR shall furnish a water-measuring device in good working condition, mounted on each transit mix truck, for measuring the water added to the mix on the site. All water tanks on transit mix trucks shall be filled prior to being batched and arrive at the construction site one hundred percent (100%) full.
5. Each load of ready mixed concrete delivered at the job shall be accompanied by the ticket in accordance with Article Delivery, Storage, and Handling.

PART 3 EXECUTION

3.01 PREPARATION

- A. Prior to placing concrete, CONTRACTOR shall remove all debris and thoroughly dampen the surfaces that may be in contact with the concrete to be placed.
- B. CONTRACTOR shall use compressed air from an air compressor to blow out construction debris and dirt at the bottom of members to be placed such as walls, beams, and columns, prior to final placement of forms that may obscure any joint. CONTRACTOR shall demonstrate to ENGINEER that all debris, such as concrete particles, saw dust, loose tie wire, bar tags, tape, trash and dirt, have been thoroughly removed.
- C. All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed shall be cleaned of all such mortar or grout before the surrounding or adjacent concrete is placed.

- D. No concrete shall be placed until all formwork, reinforcement, installation of parts to be embedded, bracing of forms, and preparation of surfaces involved in the placing have been reviewed by ENGINEER.
- E. Immediately before placing concrete, all surfaces upon or against which the concrete is to be placed shall be free from standing water, mud, debris, or loose materials.
- F. No concrete shall be placed when form surfaces that may be in contact with the concrete, reinforcement, embedded items or sub-base is less than thirty two degrees Fahrenheit (32°F). When the mean daily outdoor temperature is less than forty degrees Fahrenheit (40°F), the temperature of the concrete shall be maintained between fifty degrees Fahrenheit (50°F) and seventy degrees Fahrenheit (70°F) for the required curing period. When necessary, arrangements for heating, covering, insulating, or housing the concrete work shall be made in advance of placement and shall be adequate to maintain the required temperature without injury as a result of concentration of heat. Combustion heaters shall not be used during the first twenty four (24) hours unless precautions are taken to prevent exposure of the concrete to exhaust gases which contain carbon dioxide.
- G. Concrete shall not be placed against forms exposed to heating unless the temperature of the forms is first cooled to less than or equal to ninety degrees Fahrenheit ($\leq 90^{\circ}\text{F}$).

3.02 PLACEMENT

- A. Placement shall conform to ACI 301, Chapter 8, ACI 304, ACI 306.1, ACI 305.1, and ACI 309. No concrete shall be placed in water except with the written permission of ENGINEER. The surfaces of absorptive materials against or upon which concrete is to be placed shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete. The concrete shall be placed by equipment that will prevent segregation or loss of ingredients. The stream of concrete shall not be allowed to separate by permitting it to fall freely over rods, spacers or other embedded materials.
- B. Unless otherwise called out in these SPECIFICATIONS or shown on the DRAWINGS, the placement lift depth of concrete in walls shall be limited to two (2) feet or less to minimize surface defects such as air voids that can form on concrete surfaces. Lift depths shall be limited to one (1) foot if, in the opinion of ENGINEER, the quality of the finish is unacceptable at the two- (2-) foot lift depth.
- C. Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement.
- D. Concrete shall not be dropped more than five (5) feet unless confined by closed chutes or pipes. Care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred and strain shall not be placed on the ends of projecting reinforcement.
- E. Where steep slopes are required, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement.
- F. Concrete shall not be pumped through aluminum alloy pipe.

- G. All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete.

3.03 CONSOLIDATION

- A. Concrete vibrators for consolidating concrete shall be two and one-half inch (2-1/2") diameter "high cycle" vibrators with a frequency under load of eight thousand (8,000) to ten thousand four hundred (10,400) vibrations per minute (vpm). Concrete vibrators of lesser capacity are unacceptable for use in any part of the construction. CONTRACTOR shall have at least one standby concrete vibrator ready for use for every two (2) concrete vibrators in use during a concrete placement.
- B. All concrete shall be thoroughly consolidated with internal vibrators as recommended in ACI 309 immediately after deposition. The concrete shall be thoroughly worked around the reinforcing steel, around embedded items and into corners of forms. Vibration shall be supplemented by spading, rodding, or forking to eliminate all honeycomb and voids around embedded items.
- C. The vibrator shall be inserted vertically, allowing it to penetrate rapidly to the bottom of the lift and at least six (6) inches into the previous lift. The vibrator shall be held at the bottom of lift for five to fifteen (5 - 15) seconds. The vibrator shall be pulled up at a rate of about three (3) inches per second.
- D. The vibrator shall be inserted so that the fields of action overlap. The field of action is approximately eight (8) times the vibrator's head diameter. Thus for a two and one-half (2-1/2) inch diameter vibrator, the spacing of each insertion shall be approximately twenty (20) inches.
- E. Vibration shall be stopped when the concrete surface takes a sheen and large air bubbles no longer escape.
- F. Do not use a vibrator to move concrete horizontally.

3.04 OPENINGS AND INSERTS

- A. Pipe sleeves, inserts for pipe connections, anchors, and forms for pipe holes shall be accurately placed and securely fastened to the forms in such a manner that the placing of concrete shall not alter their alignment or location. In the event that openings are inadvertently omitted or improperly placed, ENGINEER may require the concrete to be cored at the proper location. Filling of improperly placed openings shall be done with expansive grout or dry pack or mortar applied with an accepted epoxy adhesive. The surfaces of the opening shall be roughened prior to filling.

3.05 EMBEDDED ITEMS

- A. At the time of concrete placement, embedded items shall be clean and free from mud, oil, and other coatings that may adversely affect bonding capacity. Aluminum embedments shall be coated with a bituminous material to prevent electrolytic action between the embedded item and reinforcing steel that results in concrete deterioration. Embedment items shall be accurately placed and securely fastened to the forms in such a manner that the placing of concrete shall not alter their alignment or location. Contact between embedded items and reinforcing steel or tendon ducts is unacceptable and is not permitted.

3.06 CONSTRUCTION JOINTS

- A. The location of all construction joints shall be subject to the acceptance of ENGINEER. The surface of all construction joints shall be thoroughly cleaned and all laitance and standing water removed. Clean aggregate shall be exposed by abrasive blast cleaning. Wire brushing and air water jets may be used while concrete is fresh provided results are equal to abrasive blast cleaning. Construction joints shall be keyed at right angle to the direction of shear. Except where otherwise shown on the DRAWINGS, keyways shall be at least one and one-half (1-1/2) inch in depth over at least twenty five percent (25%) of the area of the section.

3.07 EVAPORATIVE RETARDANT

- A. The use of an evaporative retardant is required to assist in proper placement of concrete in accordance with Section 03 29 00, Concrete Curing. Apply two (2) times; after screeding and after the first floating operation. The retardant should be applied at a rate of one (1) gallon of sprayable solution per two hundred to four hundred (200 - 400) square feet by spraying with an industrial type sprayer. If the nozzle of the sprayer becomes plugged, CONTRACTOR shall clean, or replace, the nozzle. Under no circumstances shall the retardant be used except by spraying a mist with a nozzle. The retardant shall be applied in strict conformance with the manufacturer's recommendations and precautions. In no case shall the retardant be used as a finishing agent. The use of an evaporative retardant requires review and approval by ENGINEER.

3.08 FIELD QUALITY CONTROL

- A. CONTRACTOR shall assist OWNER or the concrete testing consultant as requested during the performance of quality control testing. When concrete is placed using a concrete pumper, concrete for testing will be taken from the pumper discharge hose.

END OF SECTION

SECTION 03 31 01

SCULPTED CONCRETE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. CONTRACTOR shall furnish all labor, tools, and equipment for the construction of reinforced cast-in-place sculpted concrete (concrete and Shotcrete). Where “sculpted concrete” is called out on the DRAWINGS, it shall be up to the CONTRACTOR whether to use concrete and Shotcrete or just Shotcrete as necessary to conform to the lines, grades, thicknesses, and typical cross sections shown on the DRAWINGS. Sculpted concrete is to be finished to look like natural rock where exposed above ground.
- B. Work includes preparation of substrate surface, placing reinforcing steel, and placement and shaping of the top concrete or Shotcrete surface to look like natural sedimentary rock, and related items as shown or specified.
- C. This section includes basic finishing and curing methods, accessory control, and expansion and contraction joint devices.

1.02 RELATED SECTIONS

- A. The following is a list of SPECIFICATIONS which may be related to this section:
 - 1. Section 03 31 00, Structural Concrete.
 - 2. Section 03 11 00, Concrete Forming.
 - 3. Section 03 15 00, Construction Joints.
 - 4. Section 03 15 13, Waterstops.
 - 5. Section 03 21 00, Reinforcing Steel.
 - 6. Section 03 35 00, Concrete Finishing.
 - 7. Section 03 39 00, Concrete Curing.
 - 8. Section 07 92 00, Sealants.

1.03 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. ASTM International (ASTM):
 - a. C33, Standard Specification for Concrete Aggregates.
 - b. C94/C94M, Standard Specification for Ready-Mixed Concrete.

- c. C150, Standard Specification for Portland Cement.
- d. C260, Standard Specification for Air-entraining Admixtures for Concrete.
- e. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.
- f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
- g. C979, Standard Specification for Pigments for Integrally Colored Concrete.
- h. C1059, Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete.
- i. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
2. American Concrete Institute (ACI):
 - a. 211, Standard Practice for Selecting Proportions for Concrete.
 - b. 301, Specifications for Structural Concrete.
 - c. 304, Guide for Measuring, Mixing, Transporting and Placing Concrete.
 - d. 305.1, Specification for Hot Weather Concreting.
 - e. 306.1, Specification for Cold Weather Concreting.
 - f. 309, Standard Practice for Consolidating Concrete.
 - g. 318, Building Code Requirements for Structural Concrete.
 - h. 504, Guide to Joint Sealants.
 - i. 506, Recommended Practice for Shotcreteing

1.04 SUBMITTALS

- A. Provide product data on the following:
 1. Ready-mixed concrete or Shotcrete mix designs.
 2. Fly ash.
 3. Admixtures (such as air-entraining and water-reducing admixtures).
 4. Form release agents.
 5. Bonding agents.
 6. Grout.

7. Concrete coloring pigment.
8. Data for proprietary materials and items including patching compounds, curing compounds, and other requested by the ENGINEER.
9. Contractor statement detailing previous sculpted concrete experience.
10. A sculpted concrete construction plan is to be submitted in writing to the ENGINEER for review 7 days prior to construction. The plan shall describe methods and equipment proposed for hauling, placing, curing, and protecting sculpted concrete as well as placement schedules indicating anticipated daily progress.
11. Shop drawings for sculpted concrete feature indicating sizes, spacing, locations, and quantities of reinforcing steel, bending and cutting schedules, splicing, supporting and spacing devices, and other accessories.
12. The CONTRACTOR shall construct a sample sculpted concrete panel measuring not less than 50 square feet. The sample panel shall represent the finished surface texturing, coloring, and etching of the sculpted concrete feature. The ENGINEER or other representatives of the OWNER shall observe and approve the sample panel prior to the construction of any sculpted concrete features.
13. Contractor shall submit to the ENGINEER for review and approval, all proposed texture mats to be utilized by the CONTRACTOR to achieve the most natural rock appearance and texture possible. If other methods of texturing will be performed, the contractor shall submit detailed descriptions of such methods for review.

1.05 QUALITY ASSURANCE

- A. Structural Concrete as specified in Section 03 31 00, Structural Concrete, shall be used in the construction of the sculpted concrete feature unless Shotcrete is previously approved.
- B. Prior to placement of structural concrete for the sculpted concrete feature, the ENGINEER or other representatives of the OWNER must observe all reinforcing bar, forms, and surfaces receiving concrete. Prior to placing concrete CONTRACTOR must repair all discrepancies identified by ENGINEER or other representatives of the OWNER.
- C. OWNER's Direction:
 1. It is intended that the finished sculpted concrete feature simulate natural rock as shown on the DRAWINGS. OWNER's direction and aesthetic intentions are specified herein.
 2. To achieve the natural rock simulation, the CONTRACTOR shall coordinate fully with ENGINEER or other representatives of the OWNER. The ENGINEER or OWNER explicitly reserves the right to continuously monitor the WORK for aesthetic quality until the desired effects are achieved.

3. All WORK in this section shall be observed by the ENGINEER or other representatives of the OWNER. CONTRACTOR shall ensure a representative of the OWNER is onsite prior to placement of concrete.
 4. For sculpted concrete work, visits to other project sites (to view examples) may be required. Adequate notification of the intent to begin WORK on this item (minimum 24 hours) is required to ensure inspection and oversight by the ENGINEER and/or OWNER.
- D. The fabrication of artificial rockwork and placement, installation, and/or adjustment of finish details and sculptures shall be accomplished in such a manner as to appear as realistic as possible and “read right” to the trained eye. This element is artistic in nature and may require field adjustments to completed work to obtain the desired effect. The ENGINEER will decide questions of aesthetic effect. Minor changes or adjustments to in-place work shall be made at the CONTRACTOR’s expense.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Structural concrete delivery, storage, and handling shall be performed in accordance with Section 03 31 00, Structural Concrete.
- B. Ready-mixed Shotcrete shall comply with ASTM C94 except that it may be delivered to the Shotcrete equipment in the dry state if that equipment is capable of adding the water and mixing satisfactorily with the dry ingredients, or with ASTM C685, in which case the ingredients are delivered dry and proportioned and mixed at the site.
- C. Structural reinforcing steel delivery, storage, and handling shall be performed in accordance with Section 03 21 00, Reinforcing Steel.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Definition: Where “sculpted concrete” is called out on the plans, concrete or Shotcrete shall be used as necessary to meet the thickness, lines, and grades indicated on the plans.
- B. Concrete class:
 1. Concrete
 - a. Concrete shall meet the requirements of Class B concrete in accordance with section 601 of the Colorado Department of Transportation “Standard Specifications for Road and Bridge Construction”.
 - b. The concrete mix shall be made with AASHTO M 43 size No. 8 coarse aggregate.

Sieve size U.S. Standard Square Mesh Sieves	ASHTO M 43 size No. 8 coarse aggregate Percent by Weight Passing
3/4"	-
1/2"	100
3/8"	85-100
No. 4	10-30
No. 8	0-10
No.16	0-5

2. Shotcrete
 - a. Shotcrete shall be placed as a wet mixture of aggregate and Portland cement.
 - b. The minimum 28-day compressive strength shall be 4500 psi.
 - c. Coarse aggregates
 - 1) AASHTO M 43 Size No. 8

Sieve size U.S. Standard Square Mesh Sieves	ASHTO M 43 size No. 8 coarse aggregate Percent by Weight Passing
3/4"	-
1/2"	100
3/8"	85-100
No. 4	10-30
No. 8	0-10
No.16	0-5

- d. Fine aggregates
 - 1) AASHTO M6
 - 2) ASTM C33

Sieve size U.S. Standard Square Mesh Sieves	ASTM C33 Fine Aggregate Percent by Weight Passing
3/4"	-
1/2"	-
3/8"	100
No. 4	95-100
No. 8	80-100
No.30	50-85
No. 50	25-60
No. 100	2-10

- C. Use cement conforming to one of the following:
 - 1. Portland Cement conforming to ASTM C-150. Use only one brand of cement throughout the project.
 - 2. Blended hydraulic cement conforming to ASTM C-595 type IS, IS-A, IP, or IP-.
- D. Water shall be clean and free from injurious amounts of oil, acid, alkali, organic matter or other deleterious substances. For finished Shotcrete, use curing water that is free from elements that could cause staining.
- E. Submit for acceptance proportioning and test data from prior experience. If data from prior experience are not available or accepted, make and have tested specimens from three or more different mix proportions. Submit mix design containing recommended mix proportions and test results for acceptance of ready-mixed Shotcrete. Air entrainment shall be 5-8% prior to pumping.
- F. General: Structural concrete shall conform to Section 03 31 00, Structural Concrete. Structural reinforcing steel shall conform to Section 03 21 00, Reinforcing Steel.
- G. Concrete Pigment: Concrete coloring shall conform to ASTM C979.
- H. Fibermesh: Fibermesh shall not be allowed in sculpted concrete features unless written approval is provided by ENGINEER.
- I. Reinforcing Steel: reinforcing steel shall meet the requirements of section 03 21 00 Reinforcing Steel.

2.02 COMPRESSIVE STRENGTH

- A. Concrete compressive strength shall conform to Section 03 31 00, Structural Concrete.

2.03 SOURCE QUALITY CONTROL

- A. Batching, Mixing, Transporting Mixed Concrete; Mixed Concrete or Truck Mixers: Shall comply with Section 03 31 00, Structural Concrete.

2.04 ADMIXTURES

- A. Use of admixtures shall be permitted upon approval by the ENGINEER.

2.05 STAINING

- A. See section 09 91 00 of these specifications for information related to staining sculpted concrete.

PART 3 EXECUTION

3.01 EQUIPMENT

- A. All Shotcrete shall be applied to the substrate surface via pneumatic-feed or positive displacement guns. All guns, air compressors, delivery hoses, and nozzles shall work

together to provide the appropriate Shotcrete product as determined acceptable by the ENGINEER. Failure to meet the desired product and strengths may result in rejection of equipment and/or methods employed by the CONTRACTOR at the discretion of the ENGINEER.

3.02 GENERAL

- A. “Sculpted concrete” shall be constructed with a single layer of concrete or Shotcrete. The CONTRACTOR is responsible for reviewing the DRAWINGS and deciding which application method will maintain the intended shape and grades. Any other application approach must be reviewed and approved by the ENGINEER.
- B. The “Test Section” shall be constructed first. This section will be inspected by the ENGINEER and OWNER. Once deemed acceptable and any necessary modifications to future work are discussed and agreed upon, the CONTRACTOR shall commence construction on other sculpted concrete. There is no specified sequence for the other areas.

3.03 PREPARATION

- A. Excavation to subgrade shall be carefully considered by the CONTRACTOR. Subgrade may be sloped uniformly, or stepped in accordance with the grading shown on the DRAWINGS as a means of reducing the concrete/Shotcrete quantity required. No adjustment in quantity shall be made for concrete/Shotcrete placed at thicknesses greater than the uniform layer shown on the DRAWINGS. The building of earthen steps on top of a sloping subgrade plane that has been compacted and approved is strictly prohibited. All concrete/Shotcrete necessary to achieve the layout shown on the DRAWINGS shall be included in the unit cost of the sculpted concrete.
- B. Prior to placing concrete, CONTRACTOR shall remove all debris and thoroughly dampen the surfaces that may be in contact with the concrete to be placed.
- C. CONTRACTOR shall examine the subgrade, and the conditions under which concrete reinforcement is to be placed, and correct conditions that would prevent the proper and timely completion of the work. The subgrade shall be free of water, unfrozen, mud, debris, or loose materials and have met compaction requirements as specific in section 31 23 00. CONTRACTOR shall not proceed with the work until unsatisfactory conditions have been corrected.

A Shotcrete flash coat may be applied over the top of the completed subgrade. The flash coat shall consist of a 1-inch layer of Shotcrete that will cap and protect the subgrade material during placement of reinforcing steel and prior to placement of sculpted concrete. The flash coat thickness can be counted towards the total required thickness of sculpted concrete if the following conditions are met: This requirement may be waived by OWNER or ENGINEER if CONTRACTOR can demonstrate it is not required and will not compromise the quality of the structure.

1. The thickness of the flash coat does not exceed 1.5 inches
2. The flash coat is power washed clean after steel placement is complete.

3. The flash coat Shotcrete does not excessively crack, break apart, and/or separate from the subgrade prior to placement of sculpted concrete. Determination of acceptance shall be performed by the ENGINEER.
- D. CONTRACTOR shall use compressed air from an air compressor to blow out construction debris and dirt at the bottom of members to be placed such as walls, beams, and columns, prior to final placement of forms that may obscure any joint. CONTRACTOR shall demonstrate to ENGINEER that all debris, such as concrete particles, saw dust, loose tie wire, bar tags, tape, trash, and dirt, have been thoroughly removed.
- E. All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed shall be cleaned of all such mortar or grout before the surrounding or adjacent concrete is placed.
- F. No concrete shall be placed until all formwork, reinforcement, installation of parts to be embedded, bracing of forms, and preparation of surfaces involved in the placing have been reviewed by ENGINEER.
- G. Concrete shall be placed when form surfaces that may be in contact with the concrete, reinforcement, embedded items or sub-base are greater than thirty-two degrees Fahrenheit (32°F). When the mean daily outdoor temperature is less than forty degrees Fahrenheit (40°F), the temperature of the concrete shall be maintained between fifty degrees Fahrenheit (50°F) and seventy degrees Fahrenheit (70°F) for the required curing period. When necessary, arrangements for heating, covering, insulating, or housing the concrete work shall be made in advance of placement and shall be adequate to maintain the required temperature without injury as a result of concentration of heat. Combustion heaters shall not be used during the first twenty four (24) hours unless precautions are taken to prevent exposure of the concrete to exhaust gases which contain carbon dioxide.
- H. Concrete shall not be placed against forms exposed to heating unless the temperature of the forms is first cooled to less than or equal to ninety degrees Fahrenheit ($\leq 90^{\circ}\text{F}$).

3.04 CONCRETE PLACEMENT

- A. Concrete shall be placed directly on approved subgrade in accordance with the requirements set for in Section 03 31 00.
- B. Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement.
- C. Concrete shall not be dropped more than five (5) feet unless confined by closed chutes or pipes. Care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred and strain shall not be placed on the ends of projecting reinforcement.
- D. Where steep slopes are required, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement.
- E. Concrete shall not be pumped through aluminum alloy pipe.

- F. All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete.

3.05 SHOTCRETE PLACEMENT

- A. Place Shotcrete using suitable delivery equipment and procedures that will meet the requirements of this specification. Refer to ACI Standard 506-66, Recommended Practice for Shotcreteing.
- B. Do not place Shotcrete if drying or stiffening of the mix takes place at any time prior to delivery to the nozzle. Do not use rebound or previously expended material in the Shotcrete mix.
- C. Remove over-spray or rebound prior to final set and before placement of Shotcrete material on such adjacent surfaces.
- D. Placement Techniques:
 - 1. Control thickness, method of support, air pressure, and/or water content of Shotcrete to preclude sagging or sloughing off. Discontinue Shotcreteing or provide suitable means to screen the nozzle stream if wind or air currents cause separation of the nozzle stream during placement.
 - 2. Dampen absorptive substrate surfaces prior to placement of Shotcrete to facilitate bond and to reduce the possibility of shrinkage cracking developing from premature loss of the mixing water.
 - 3. Broom or scarify the surface of freshly placed Shotcrete to which, after hardening, additional layers of Shotcrete are to be bonded. Dampen surface just prior to application of succeeding layers.
 - 4. Provide a supply of clean dry air adequate for maintaining sufficient nozzle velocity for all parts of the Work, and if required, for simultaneous operation of a suitable blow pipe for clearing away rebound.
- E. Placement Around Reinforcement:
 - 1. Hold the nozzle at such a distance and angle to place material behind reinforcement before any material is allowed to accumulate on its face. In the dry-mix process additional waste may be added to the mix when encasing reinforcement to facilitate a smooth flow of material behind the bars.
 - 2. Do not place Shotcrete through more than one layer of reinforcing steel rods or mesh in one application unless demonstrated by pre-construction tests that steel is properly encased. Test to ascertain if any voids or sand pockets have developed around or behind reinforcement by probing with an awl or other pointed tool; by removal of randomly selected bars; or by coring or other suitable means.

3.06 COVER OF REINFORCEMENT

- A. Place concrete and/or Shotcrete to provide the 1 ½" (minimum) cover over all reinforcement.

3.07 LINE AND THICKNESS CONTROL

- A. Use adequate ground wires or other accepted means to establish the thickness, surface planes, and finish lines of the concrete/Shotcrete.
- B. No additional payment will be made for concrete volume or steel reinforcement placed in excess of amounts shown on the DRAWINGS, unless the ENGINEER agrees that conditions warrant such a change that go beyond the requirements set forth in Section 3.03(A) of this SPECIFICATION. If the CONTRACTOR prepares the subgrade in such a manner requiring additional concrete to meet design lines and grades without ENGINEER approval, the ENGINEER may require additional reinforcement steel at no additional charge to the OWNER.

3.08 CONSOLIDATION

- A. Concrete vibrators for consolidating concrete shall be two and one-half inch (2-1/2") diameter "high cycle" vibrators with a frequency under load of eight thousand (8,000) to ten thousand four hundred (10,400) vibrations per minute (vpm). Concrete vibrators of lesser capacity are unacceptable for use in any part of the construction. CONTRACTOR shall have at least one standby concrete vibrator ready for use for every two (2) concrete vibrators in use during a concrete placement.
- B. All concrete shall be thoroughly consolidated with internal vibrators as recommended in ACI 309 immediately after deposition. The concrete shall be thoroughly worked around the reinforcing steel, around embedded items, and into corners of forms. Vibration shall be supplemented by spading, rodding, or forking to eliminate all honeycomb and voids around embedded items.
- C. The vibrator shall be inserted vertically, allowing it to penetrate rapidly to the bottom of the lift and at least six (6) inches into the previous lift. The vibrator shall be held at the bottom of lift for five to fifteen (5 - 15) seconds. The vibrator shall be pulled up at a rate of about three (3) inches per second.
- D. The vibrator shall be inserted so that the fields of action overlap. The field of action is approximately eight (8) times the vibrator's head diameter. Thus for a two and one-half (2-1/2) inch diameter vibrator, the spacing of each insertion shall be approximately twenty (20) inches.
- E. Vibration shall be stopped when the concrete surface takes a sheen and large air bubbles no longer escape.
- F. Do not use a vibrator to move concrete horizontally.

3.09 OPENINGS AND INSERTS

- A. Pipe sleeves, inserts for pipe connections, anchors, and forms for pipe holes shall be accurately placed and securely fastened to the forms in such a manner that the placing of concrete shall not alter their alignment or location. In the event that

openings are inadvertently omitted or improperly placed, ENGINEER may require the concrete to be cored at the proper location. Filling of improperly placed openings shall be done with expansive grout or dry pack or mortar applied with an accepted epoxy adhesive. The surfaces of the opening shall be roughened prior to filling.

3.10 EMBEDDED ITEMS

- A. At the time of concrete placement, embedded items shall be clean and free from mud, oil, and other coatings that may adversely affect bonding capacity. Aluminum embedments shall be coated with a bituminous material to prevent electrolytic action between the embedded item and reinforcing steel that results in concrete deterioration. Embedment items shall be accurately placed and securely fastened to the forms in such a manner that the placing of concrete shall not alter their alignment or location. Contact between embedded items and reinforcing steel or tendon ducts is unacceptable and is not permitted.

3.11 CONSTRUCTION JOINTS

- A. The location of all construction joints shall be subject to the acceptance of ENGINEER. The surface of all construction joints shall be thoroughly cleaned and all laitance and standing water removed. Clean aggregate shall be exposed by abrasive blast cleaning. Wire brushing and air water jets may be used while concrete is fresh provided results are equal to abrasive blast cleaning. Construction joints shall be keyed at right angle to the direction of shear. Except where otherwise shown on the DRAWINGS, keyways shall be at least one and one-half (1-1/2) inch in depth over at least twenty five percent (25%) of the area of the section.
- B. Construction joints shall not be allowed within a location where water is expected to flow over in the final constructed condition.
- C. Taper construction joints to a shallow edge form, about 1 inch thick, except where the joint will be subjected to compressive stress. In this case, use non-tapered joints and take special care to avoid or remove trapped rebound at the joint.
- D. The entire joint shall be thoroughly cleaned and wetted prior to the application of additional concrete/Shotcrete.
- E. Make joints perpendicular to the main reinforcement. Continue reinforcement across joints.
- F. Position construction and control joints to conform to the locations of natural occurring cracks and joints in the simulated rock and earth forms.

3.12 FINISHES

- A. CONTRACTOR will provide an expert(s) to perform texturing and shaping of the concrete/Shotcrete that is left exposed above ground.
- B. Finished product shall simulate natural rock as described in the SPECIFICATIONS and DRAWINGS. The CONTRACTOR shall achieve the desired appearance by 1) troweling the concrete/Shotcrete smooth, 2) cutting rock formation scars into the surface, and 3) texturing the entire surface using both texture mats and power

washing to achieve a natural rock finish. Alternative methods must be approved by ENGINEER.

- C. Extend texture layer a minimum of 3 feet below finished grade.
- D. If a trail section is included in the sculpted concrete a broom finish shall be applied to the trail surfaces shown on the DRAWINGS. Broom marks shall be perpendicular to the traveled direction. The broomed surface shall be smooth and void of sculpted concrete carvings.

3.13 CURING AND PROTECTION

A. Concrete:

- 1. Curing requirements specified in 03 39 00 Concrete Curing, shall be followed at all times.
- 2. The use of an evaporative retardant is required to assist in proper placement of concrete in accordance with Section 03 29 00, Concrete Curing. Apply two (2) times; after screeding and after the first floating operation. The retardant should be applied at a rate of one (1) gallon of sprayable solution per two hundred to four hundred (200 - 400) square feet by spraying with an industrial type sprayer. If the nozzle of the sprayer becomes plugged, CONTRACTOR shall clean or replace the nozzle. Under no circumstances shall the retardant be used except by spraying a mist with a nozzle. The retardant shall be applied in strict conformance with the manufacturer's recommendations and precautions. In no case shall the retardant be used as a finishing agent. The use of an evaporative retardant requires review and approval by ENGINEER.

B. Shotcrete:

- 1. Initial Curing
 - a. Following curing procedures of ACI Standard 308. Immediately after finishing, keep Shotcrete continuously moist for at least 24 hours. The methods and materials used for curing shall be approved by ENGINEER prior to placing Shotcrete.
- 2. Final Curing
 - a. Provide additional curing immediately following the initial curing and before the Shotcrete has dried. Use one of the following materials or methods:
 - 1) Continue the method used in initial curing.
 - 2) Materials conforming to "Specifications for Sheet Materials for Curing Concrete," (ASTM C171).
 - 3) Other moisture retaining coverings accepted upon approval by ENGINEER.

C. Duration and Temperature of Curing

1. Continue curing for the first 7 days after installation or for the first 3 days if high early strength is obtained. During the curing period, maintain Shotcrete or concrete above 40°F and in a moist condition as specified above. Prevent rapid drying at the end of the curing period

3.14 REPAIR OF SURFACE DEFECTS

- A. Remove and replace concrete or Shotcrete, which lacks uniformity, exhibits segregation, honeycombing, or lamination, or which, contains any dry patches, slugs, voids or sand pockets. Remove and replace damaged in-place concrete or Shotcrete.
- B. Replace any concrete or Shotcrete which subsides after placement.

3.15 FIELD QUALITY CONTROL

- A. CONTRACTOR shall assist OWNER or the concrete testing consultant as requested during the performance of quality control testing. Testing will be taken from the concrete truck.
- B. Test panels shall be shot for the Shotcrete. The panels should be 18" by 18" by 3" and shot at the same orientation as the majority of the structure. Panels shall be shot for every day of placement and every 25 CY of Shotcrete placed. All panels should be cured at the project site. Cores should be taken from the panel in accordance with ASTM C 42. Cores will be used to verify compressive strength. CONTRACTOR is to provide the panels for use in Shotcrete testing and have them available in the field prior to the start of Shotcrete. CONTRACTOR is to notify the ENGINEER 48 hours in advance of the start of Shotcrete operations.

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SECTION 03 35 00

CONCRETE FINISHING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. CONTRACTOR shall supply all labor, tools, equipment, and materials to finish properly placed concrete for structures.

1.02 RELATED SECTIONS

- A. The following is a list of SPECIFICATIONS which may be related to this section:
 - 1. Section 03 11 00, Concrete Forming.
 - 2. Section 03 31 00, Structural Concrete.
 - 3. Section 03 60 00, Grouting.
 - 4. Section 32 16 00, Sidewalks, Curbs, and Gutters.

1.03 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American Concrete Institute (ACI):
 - a. 116, Cement and Concrete Terminology.
 - b. 121, Quality Assurance Systems for Concrete Construction.
 - c. SP-15, ACI 301 Field Reference Manual.
 - d. 309, Identification and Control of Consolidation-Related Surface Defects in Formed Concrete.
 - e. 311, Guide for Inspection of Concrete.
 - 2. ASTM International (ASTM):
 - a. C33, Standard Specification for Concrete Aggregates.
 - b. C150, Standard Specification for Portland Cement.
 - 3. U.S. Department of Interior—Bureau of Reclamation (USBR):
 - a. M-47, Standard Specifications for Repair of Concrete.

1.04 SUBMITTALS

- A. Provide product data on the following:

1. Grout.
2. Bonding agent.
3. Method of repairing defects, unless otherwise called out herein.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver the materials to the PROJECT site in the manufacturer's containers with all labels intact and legible at the time of use. Materials shall be stored in a secure, indoor, dry area. Maintain grouts and aggregates in a dry condition during delivery, storage, and handling.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Premixed Pre-Packaged Grout:
 1. Master Builders; EMACO R320.
 2. Master Builders; EMACO S66-CR.
- B. Epoxy Bonding Agent:
 1. Master Builders; Concesive Liquid (LPL).
 2. Master Builders; Concesive Standard Liquid.
- C. Cement:
 1. ASTM C150, Type to match original concrete surface.
- D. Aggregate:
 1. ASTM C33, one hundred percent (100%) passing the No. 30 mesh sieve.
- E. Bond Coat Mortar:
 1. Mortar used to bond patching mortar shall be made of the same materials and of approximately the same proportions as used for the concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of one (1) part cement to not more than one (1) part sand by damp loose volume.
- F. Patching Mortar:
 1. Patching mixture shall be made of the same materials and of approximately the same proportions as used for the concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of one (1) part cement to not more than two and one-half (2-1/2) parts sand by damp loose volume. White Portland cement shall be substituted for a part of the gray Portland cement on exposed concrete in order to produce a color matching the color of the surrounding concrete, as determined by a trial patch. The quantity of mixing water shall be no more than necessary for handling and placing. The patching mortar shall be

mixed in advance and allowed to stand with frequent manipulation with a trowel, without addition of water, until it has reached the stiffest consistency that shall permit placing.

G. Water:

1. Only clean potable water shall be used. A calibrated measuring device is required for measuring the proper amount of water to be added to pre-packaged grouts and mortars.

PART 3 EXECUTION

3.01 PREPARATION

A. The means and methods of repair of improperly placed or finished concrete shall be reviewed by ENGINEER prior to performing the WORK. Regardless of prior approval of the means and methods of concrete finish repair, no concrete finish shall be repaired until ENGINEER has reviewed the existing finish. This includes defects caused by ineffective and improper vibration such as honeycomb, excessive air voids on formed surfaces, placement “pour” lines (cold joints), and sand streaking. It also includes defects caused by excessive form deflections, form damage, or form failure.

B. Repair of Surface Defects:

1. Surface defects, unless otherwise specified by the CONTRACT DOCUMENTS, shall be repaired immediately after form removal, but not before review by ENGINEER. The surface temperature of the concrete shall be fifty degrees Fahrenheit (50°F) and rising. CONTRACTOR shall measure surface temperatures when requested by ENGINEER. If necessary, CONTRACTOR shall enclose and heat the area to be repaired to bring the surface temperature of the concrete and air temperature to acceptable levels, and to permit proper curing.
2. All honeycombed and other defective concrete shall be removed down to sound concrete. If chipping is necessary, the edges shall be perpendicular to the surface or slightly undercut. Feathered edges shall not be permitted. The area to be patched and an area at least six (6) inches wide surrounding it shall be dampened to prevent absorption of water from the patching mortar. A bonding grout shall be prepared, mixed to the consistency of thick cream, and after surface water has evaporated from the area to be patched, well brushed into the surface.
3. When the bond coat begins to lose the water sheen, the premixed patching mortar shall be applied. The mortar shall be thoroughly consolidated into place and struck off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, it shall be left undisturbed for at least one (1) hour before being finally finished. The patched area shall be kept damp for seven (7) days. Metal tools shall not be used in finishing a patch in a formed wall that shall be exposed.

C. Alternative Surface Defect Repairs:

1. Certain types of defects may require the use proprietary compounds for adhesion or as patching ingredients. ENGINEER shall review these defects and request means and methods for these repairs from CONTRACTOR.
2. In lieu of, or in addition to, the foregoing patching procedures using bond coat and patching mortars, epoxy bonding agents and premixed pre-packaged grouts may be used for repair of defective areas. Such compounds shall be used in accordance with the manufacturer's written recommendations and directions. ENGINEER shall review and provide written acceptance of these procedures.

3.02 APPLICATION

A. Tie Holes:

1. Unless otherwise called out in the DRAWINGS tie holes shall be finished as specified herein.
2. Water Retaining Structures and Below grade Vaults with Breakback Cone Ties: Fill tie holes solid as specified in Section 03 60 00, Grouting.
3. Other Structures: After being cleaned and thoroughly dampened, fill tie holes solid as specified in Section 03 60 00, Grouting.

B. Finishing of Formed Surfaces:

1. Finishes shall be performed as called out on the DRAWINGS and in referenced SPECIFICATIONS.
2. Smooth Form Finish: The form facing material shall produce a smooth, hard, uniform texture on the concrete. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to the practical minimum. Surface textures that result from forms with raised grain, torn surfaces, worn edges, patches, dents, or other defects shall be ground smooth or otherwise repaired.
 - a. Air Voids on Formed Surfaces: Air voids on formed surfaces deeper than one-quarter ($\frac{1}{4}$) inch shall be filled with patching mortar. The frequency and size of air voids shall be equal to or better than shown in Figure 1. The total void area is one percent (1%) of the surface area, or thirty-six hundredths (0.36) square inches. This six-inch (6") by six-inch (6") figure shall be the visual standard for acceptance of the finish that does not require filling of air voids.

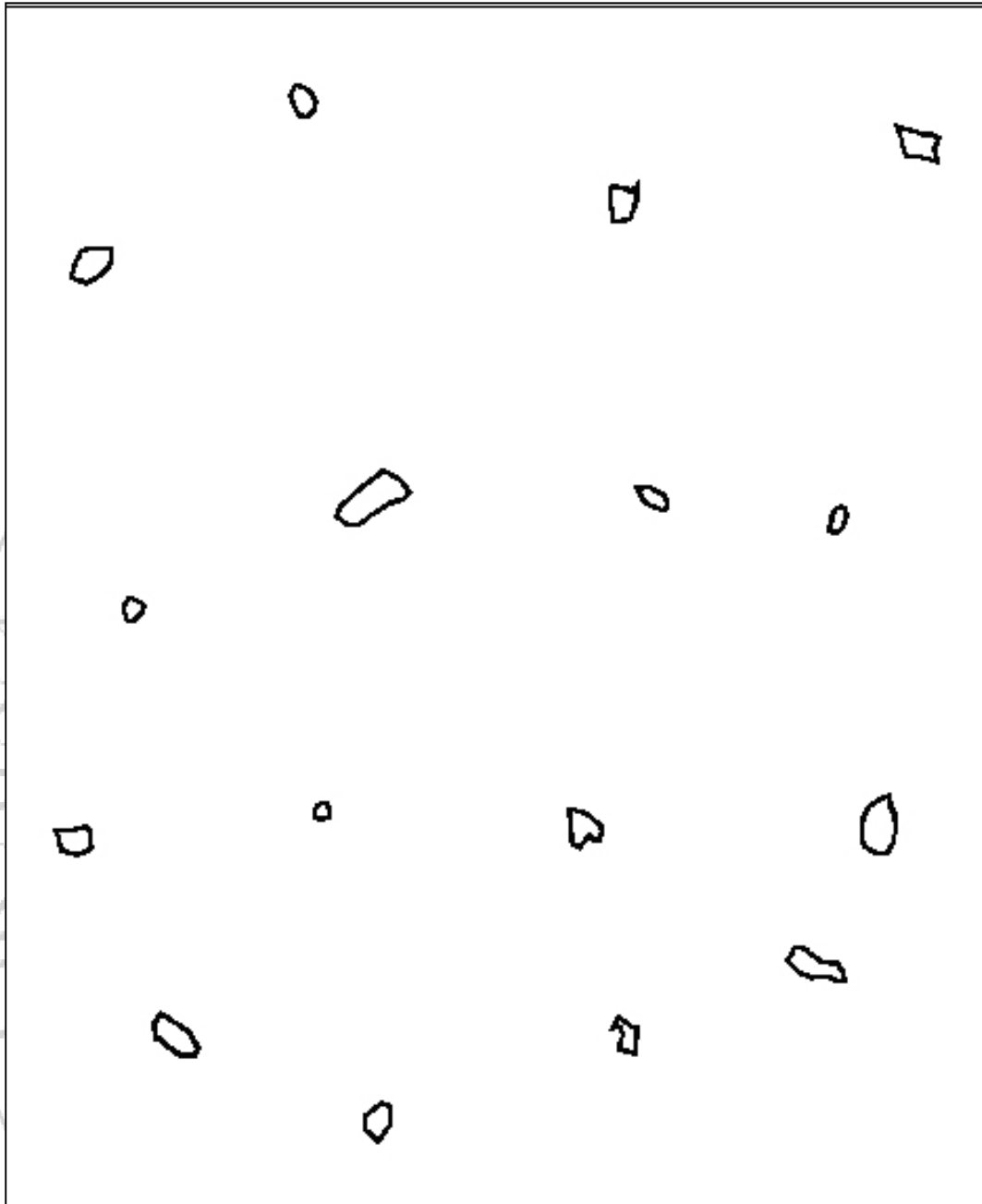


FIGURE 1

- b. Tie Holes: Tie holes shall be filled as specified in Section 03 60 00, Grouting.
 - c. Form Fins: Chip or rub off form fins exceeding one-sixteenth (1/16) inch in height.
 - d. Rock Pockets: Poorly consolidated concrete shall be removed to sound concrete and the defect repaired. ENGINEER shall outline the area to be repaired.
3. As-Cast Finish: For as-cast concrete finish form materials shall produced a sound surface.

- a. Air Voids: Fill air voids deeper than one-quarter (1/4) inch and larger than one-half (1/2) square inch. The total area of acceptable air voids is seventy-two hundredths (0.72) square inch in a six-inch (6") by six-inch (6") square.
 - b. Tie Holes: Tie holes shall be filled as specified in Section 03 60 00, Grouting.
 - c. Form Fins: Chip or rub off form fins exceeding one-eighth (1/8) inch in height.
4. Rubbed Finish: Immediately after removing the forms, form ties shall be broken back a minimum of three-quarters (3/4) inch from the surface, honeycomb, voids, and other surface defects grouted. The surfaces shall then be thoroughly dampened and rubbed with a No. 16 carborundum stone or equal abrasive to create a uniform surface paste. The rubbing shall be continued to remove all form marks and surface irregularities producing a smooth, dense surface. After setting, the surface shall then be rubbed with a No. 30 carborundum stone until the surface is smooth in texture and uniform in color. Unless otherwise shown in the DRAWINGS only exposed surfaces shall have a rubbed finish.
 5. Grout Finish: Prepare surface as described in "Rubbed Finishes" above. Mix one (1) part Portland cement and one-half (1/2) part fine sand with sufficient water to produce a grout with the consistency of thick paint. Wet surface of concrete to prevent absorption of water from grout, and apply grout uniformly with brushes. Immediately after applying grout mix, scrub the surface with a cork float or stone to coat surface and fill remaining air voids and other remaining surface defects. Remove excess grout by working the surface with rubber float. After the surface whitens from drying, rub with clean burlap. Cure surface for a period of seventy two (72) hours.

C. Finishing of Unformed Surfaces: Unless otherwise shown on the DRAWINGS unformed surfaces shall be finished as follows:

1. Slabs: Screed with straightedge to remove low and high spots bringing the surface to the required finish elevation of slope and float with a steel float at least three (3) feet in width. When the concrete has reached its initial set, finish with a steel trowel. Use a steel power trowel for large areas. Leave finish essentially free of trowel marks, uniform in texture and appearance and plane to the correct tolerance. Dusting the surface with dry cement, sand, or sprinkling with water is prohibited.
2. No wetting of concrete surfaces during slab finishing operations shall be permitted. Further, no concrete finishing operation shall be permitted while there is water on the surface of slabs and other flatwork.
3. Finishes that are exposed and subject to foot traffic shall receive a broom finish with a texture of plus or minus one-sixteenth ($\pm 1/16$) inch or as designated on the DRAWINGS.
4. Tops of Walls with Bearings: Strike smooth tops of walls and similar unformed surfaces that shall have bearings or bearing pads, and finish with a steel trowel.

5. Stairways and Sidewalks: Strike smooth tops of stairs and sidewalks and finish with a light broom providing a texture of plus or minus one-sixteenth ($\pm 1/16$) inch.
6. Slabs with Waterproofing Membranes: Strike smooth and float finish.
7. Construction Joint Surfaces: Surface shall be broom or raked finished. Surface shall be water or grit blasted prior to placing additional concrete, such as columns on column footings and column footings on reservoir slabs.

END OF SECTION





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SECTION 03 39 00
CONCRETE CURING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. CONTRACTOR shall furnish all labor, tools, and equipment for curing plain, reinforced, and post-tensioned, and cast-in-place concrete.

1.02 RELATED WORK

- A. The following is a list of SPECIFICATIONS which may be related to this section:
 - 1. Section 03 15 00, Construction Joints.
 - 2. Section 03 31 00, Structural Concrete.
 - 3. Section 03 35 00, Concrete Finishing.

1.03 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American Concrete Institute (ACI):
 - a. 305.1, Specification for Hot Weather Concreting.
 - b. 306.1, Specification for Cold Weather Concreting.
 - c. 308.1, Standard Practice for Curing Concrete.
 - 2. ASTM International (ASTM):
 - a. C171, Standard Specification for Sheet Materials for Curing Concrete.
 - b. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
 - c. D2103, Standard Specification for Polyethylene Film and Sheeting.

1.04 SUBMITTALS

- A. Provide data on curing compounds, sheet materials, and methods of securing sheet materials in place.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver curing materials in manufacturer's original packaging including applicable instructions and manufacturer's safety data sheets (MSDS).

PART 2 PRODUCTS

2.01 MATERIALS

- A. Sheet Materials for Curing Concrete: White burlap-polyethylene sheeting weighing not less than ten (10) ounces per linear yard, forty (40) inches wide, impregnated on one side with white opaque polyethylene 0.004 inch thick as specified in ASTM C171 shall be used when called out in the DRAWINGS or in other applicable SPECIFICATIONS. The polyethylene shall be securely bonded to the burlap so that there will be no separation.
- B. Liquid Membrane-Forming Compounds for Curing Concrete: Liquid membrane-forming compounds for curing concrete shall and conform to ASTM C309, Type 1-D with a red or white fugitive dye. Use a white dye unless otherwise directed by ENGINEER.
- C. Polyethylene Film: Polyethylene film shall conform to ASTM D2103. The film shall have a thickness of six (6) mils and be a white opaque color.
- D. Evaporative Retardant: Confilm manufactured by Master Builders, Inc. or approved equal.
- E. Water: Only water from sources approved by ENGINEER shall be used.
- F. Penetrating Sealer and Chloride Ion Screen: Masterseal SL40 by Master Builders, Inc. or approved equal.
- G. Organic Corrosion Inhibiting Admixture: Rheocrete 222+ by Master Builders or approved equal.

PART 3 EXECUTION

3.01 GENERAL

- A. Perform the WORK in accordance with this SPECIFICATION and in accordance with applicable ACI standards. When a conflict occurs between this SPECIFICATION and ACI, the ACI standard shall control. All materials shall be used in accordance with the manufacturer's printed instructions, a copy of which shall be on site.
- B. Beginning immediately after placement, concrete shall be protected from premature drying, excessively hot or cold temperatures, and mechanical injury, and shall be maintained with minimal moisture loss at a relatively constant temperature for the period necessary for hydration of the cement and hardening of the concrete in accordance with ACI 308.1. The materials and method of curing shall be subject to review and acceptance by ENGINEER. Specific curing requirements may be called out on the DRAWINGS.
- C. Curing shall be continued for at least seven (7) days. Alternatively, if tests are made of cylinders kept adjacent to the structure and cured by the same methods, moisture retention measures may be terminated when the average compressive strength has reached seventy percent (70%) of the specified concrete strength.

3.02 CURING METHODS

- A. Perform curing of concrete by curing compound, by moist curing, by moisture-retaining cover curing, or combinations thereof, as herein specified.
- B. Provide moisture curing by one of the following methods:
 - 1. Keep concrete surface continuously wet by covering with water.
 - 2. Use continuous water-fog spray.
 - 3. Cover concrete surface with moisture retaining cover specified in Paragraph 2.01.A. Place cover to provide coverage of concrete surfaces and edges with four- (4-) inch lap over adjacent moisture retaining covers, and seal using waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
- C. Provide liquid membrane curing compound specified in Article Materials to concrete surfaces as follows:
 - 1. Apply specified curing compound to concrete slabs within one (1) hour of final finishing operations or within one (1) hour of form removal. Apply uniformly in continuous operation by spray or roller in accordance with manufacturer's directions and these SPECIFICATIONS. Recoat areas subjected to heavy rainfall within three (3) hours after initial application. Maintain continuity of coating and repair damage during curing period.
 - a. Liquid Membrane Forming Compound and Evaporative Retardant Applicators/Sprayers: Membrane curing and evaporative retardant compounds shall be applied with a sprayer capable of maintaining a constant pressure. Spraying membrane curing compounds or evaporative retardants by other methods, such as rolling, shall be approved by ENGINEER.
 - b. When a spray-applied membrane-curing compound is used, it shall be applied in two (2) coats with the second coat applied at right angles to the first coat.
 - 2. If finish materials are to be applied to the surface of concrete, follow manufacturer's recommendations to remove membrane curing compound.

3.03 APPLICATION

- A. Curing Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces for seven (7) days by moist curing with forms in place. If forms are removed prior to completion of specified seven (7) day period, continue curing by methods specified in Article Curing.
- B. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, floor topping, and other flat surfaces by application of specified curing methods in Article Curing.
- C. Other Surfaces: Unless otherwise shown on the DRAWINGS all other surfaces shall be cured using two (2) applications of a membrane-curing compound conforming to

ASTM C309. The second application shall be applied at ninety degrees Fahrenheit (90°F) to the first application.

- D. Rate of Temperature Change: Changes in temperature of the air immediately adjacent to the concrete during and immediately following the curing period shall be kept as uniform as possible and shall not exceed five degrees Fahrenheit (5°F) in any one (1) hour or fifty degrees Fahrenheit (50°F) in any twenty four (24) hour period.
- E. Cold Weather: Curing during cold weather conditions shall include the above methods except for water cure unless measures are taken to prevent freezing of the water as specified in ACI 306.1.
- F. Hot Weather: If the rate of evaporation approaches 0.2 lb/ft²/hr, as estimated by ACI 305.1, precautions against plastic shrinkage cracking are required. CONTRACTOR shall have a recording thermometer, hygrometer, and wind gage on site seven (7) days prior to first concrete placement. When necessary, provision for windbreaks, shading, fog spraying, sprinkling, ponding, or wet covering with a light colored material shall be made in advance of placement, and such protective measures shall be taken as quickly as concrete hardening and finishing operations will allow. Precautions against plastic shrinkage cracks may be required in conditions other than what is normally considered hot weather conditions.

3.04 PENETRATING SEALER AND CHLORIDE ION SCREEN

- A. Concrete that may be subjected to deicing salts, brackish water, or spray from brackish water shall be protected with a penetrating sealer and chloride ion screen that is readily absorbed into the surface of the concrete to provide a breathable, water repellant finish that does not affect the surface color or texture of the concrete. A penetrating sealer and chloride ion screen is not required if the concrete contains an organic corrosion inhibiting admixture which slows the ingress of chlorides and moisture and forms a durable, protective film at the level of reinforcing steel. Concrete to be protected includes but is not limited to exterior concrete in walkways, stairs, slabs on grade, elevated parking areas, etc. Concrete surface and air temperature adjacent to the concrete shall be at least forty degrees Fahrenheit (40°F) during application and curing of sealer. Application rate shall be as recommended by manufacturer.

3.05 PROTECTION

- A. During the curing period, the concrete shall be protected from damaging mechanical disturbances, such as load stresses, heavy shock, and excessive vibration. All finished concrete surfaces shall be protected from damage by construction equipment, materials, or methods, by application of curing procedures, and by rain or running water. Self-supporting structures shall not be loaded in such a way as to overstress the concrete.

END OF SECTION

SECTION 03 60 00

GROUTING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. CONTRACTOR shall furnish all labor, tools, and equipment for the placement of grout in tie holes and other locations as shown on the DRAWINGS and specified herein.
- B. This section includes basic mixing, application, and curing methods for grout.

1.02 RELATED SECTIONS

- A. The following is a list of SPECIFICATIONS which may be related to this section:
 - 1. Section 03 11 00, Concrete Forming.
 - 2. Section 03 15 00, Construction Joints.
 - 3. Section 03 31 00, Structural Concrete.
 - 4. Section 03 35 00, Concrete Finishing.
 - 5. Section 03 39 00, Concrete Curing.
 - 6. Section 32 16 00, Sidewalks, Curbs, and Gutters.

1.03 QUALITY STANDARDS

- A. The following is a list of standards which may be referenced in this section:
 - 1. ASTM International (ASTM):
 - a. C78, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
 - b. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
 - c. C469, Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.
 - d. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
 - e. C882, Standard Test Method for Bond Strength of Epoxy-Resin Systems used with Concrete by Slant Shear.
 - f. C1012, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to Sulfate Solution.

- g. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.

1.04 SUBMITTALS

- A. Provide product data on the following:
 - 1. Grout.
 - 2. Bonding agent.
 - 3. Curing compound.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Cement based mortar shall be delivered and stored in manufacturer's packaging until it is ready to be mixed and placed. Mortar bags shall be stored off the ground and protected from water and all other substances that may penetrate packaging.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Mortar for Tie Holes: EMACO R320.
- B. Bonding Adhesives: Concsive Liquid LPL or Concsive Standard Liquid.
- C. Water: Only clean potable water shall be used.
- D. Curing Compound: MB 429, Masterkure 100W, Masterkure 200W.
- E. (Exposed) Reinforcing Steel Coating: EMACO P22.
- F. Evaporation Reducer: Confilm Evaporation Reducer.

PART 3 EXECUTION

3.01 GENERAL

- A. CONTRACTOR shall have a printed set of manufacturer's recommendations for product use onsite for review during preparation, mixing, and application of grout.
- B. These grouts contain admixtures that increase grout strength and workability. The strength and performance of the grout is dependent on proper surface preparation, grout mixing and curing. CONTRACTOR shall be required to use a calibrated measuring device to add clean potable water to the grout mix. Water added to a grout mix without a calibrated device is cause for grout rejection, removal and re-placement.
- C. Curing is critical to prevent shrinkage cracks that can develop with grouts containing some admixtures. Curing shall begin immediately after placement.
- D. All mixing, surface preparation, handling, placing, consolidation, and other means of execution for pre-packaged mortars shall be done according to the instructions and

recommendations of the manufacturer and this SPECIFICATION. In the event that a conflict occurs between this SPECIFICATION and manufacturer's instructions, the manufacturer's instructions shall prevail in all cases.

3.02 INSTALLATION

A. Preparation:

1. Thoroughly clean the roughened surface and any exposed reinforcement of rust, dirt, loose chips, and dust. Maintain substrate in a saturated, surface-dry condition.
2. Where applicable, coat exposed reinforcing steel with EMACO P22 reinforcing steel bar protection coating prior to patching.

B. Mixing: Comply with mortar manufacturer's recommendations for water quantity. Mechanically mix with a slow speed drill (four hundred to six hundred [400 to 600] rpm) and Jiffler-type paddle. Pour approximately ninety percent (90%) of the mix water into the mixing container; then add the bagged material while continuing to mix. Add remaining water as needed. Mix time shall not exceed five (5) minutes.

C. Application:

1. Apply bonding adhesive such as Concrevice Liquid LPL or Concrevice Standard Liquid.
2. Place and finish with trowel or screed. In hot, windy, or dry conditions, where rapid surface evaporation may occur, apply evaporation reducer.

D. Curing: Apply Masterkure 200 W curing compound in accordance with label instructions.

3.03 FIELD QUALITY CONTROL

A. Field Tests:

1. When OWNER is to perform grout testing, CONTRACTOR shall assist OWNER or the concrete testing consultant as requested during the performance of quality control testing.
2. When prescribed in the DRAWINGS or by these SPECIFICATIONS, length change test specimens will be taken during construction from the first placement of each type of mortar, and at intervals thereafter as selected by ENGINEER to ensure continued compliance with these SPECIFICATIONS. Unless otherwise specified on the DRAWINGS or SPECIFICATIONS the testing will be performed by OWNER or testing representative.
3. When required, length change tests and fabrication of specimens for cement-based mortar shall be performed as specified in ASTM C1012 at intervals during construction as selected by ENGINEER. A set of three (3) specimens will be made for testing at seven (7) and twenty eight (28) days.

4. All mortar, already placed, that fails to meet the requirements of this SPECIFICATION, shall be subject to removal and replacement at the cost of CONTRACTOR.
5. Unless otherwise specified in the DRAWINGS or SPECIFICATIONS, the cost of all laboratory tests on grout shall be borne by OWNER, but CONTRACTOR shall assist ENGINEER in obtaining specimens for testing. However, CONTRACTOR shall be charged for the cost of any additional tests and investigation of WORK performed which does not meet the SPECIFICATIONS.

END OF SECTION

