

SECTION 03 05 00

CONCRETE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concrete:
 - a. Concrete mixes.
 - b. Form materials.
 - c. Reinforcing materials.
 - d. Water stops.
 - e. Grout mixes.
2. Grouting:
 - a. Portland cement grout.
 - b. Rapid-curing epoxy grout.
 - c. Non-shrink cementitious grout.
3. Initial and final curing of horizontal and vertical concrete surfaces.

B. Requirements:

1. Scope:
 - a. Contractor shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install concrete, reinforcing, and related materials.
 - b. The Work includes:
 - 1) Providing concrete consisting of Portland Cement, fine and coarse aggregates, water, and approved admixtures; combined, mixed, transported, placed, finished, and cured.
 - 2) Fabricating and placing reinforcing, including ties and supports.
 - 3) Design, erection, and removal of formwork.
 - 4) Building into the concrete all sleeves, frames, anchorage devices, inserts, and other items required to be embedded in concrete.
 - 5) Providing openings in concrete as required to accommodate Work under this and other Sections, and work under other contracts.
2. Coordination:
 - a. Review installation procedures under other Sections and coordinate installation of items to be installed in the concrete Work.
3. Classifications of Concrete:
 - a. The requirements in this section shall apply to the following types of concrete:
 - 1) Class A1 Concrete: Normal weight structural concrete to be used in all structures, sidewalks and pavements, except where noted otherwise in the Contract Documents. All concrete shall be Class A1 concrete unless another class is specifically called for on Contract Documents or specified herein.
 - 2) Class A2 Concrete: Not Used
 - 3) Class A3 Concrete: Normal weight structural concrete to be used where specifically called for on Contract Drawings or where specifically

- requested by Contractor and approved by Engineer. Class A3 concrete shall be similar to Class A1 except Class A3 concrete shall contain a mandatory addition of high range water reducer to aid in placement of concrete.
- 4) Class A4 Concrete: Not Used
 - 5) Class A5 Concrete: Not Used
 - 6) Class A6 Concrete: Normal weight structural concrete used where concrete is placed under pressure (pumped). Class A6 concrete shall be used only where specifically approved by Engineer.
 - 7) Class B Concrete: Normal weight structural concrete used for duct bank encasements, catch basins, fence and guard post embedment, concrete fill, and other areas where specifically noted on Contract Drawings.
 - 8) Class C Concrete: Not Used

1.2 REFERENCES

- A. Standards referenced in this Section are:
1. ACI 224R, Control of Cracking in Concrete Structures.
 2. ACI 301, Specifications for Structural Concrete for Buildings.
 3. ACI 302R, Guide for Concrete Floor and Slab Construction.
 4. ACI 304R, Guide for Measuring, Mixing, Transporting and Placing Concrete.
 5. ACI 305R, Hot Weather Concreting.
 6. ACI 306R, Cold Weather Concreting.
 7. ACI 308.1 – Specification for Curing Concrete.
 8. ACI 309R, Guide for Consolidation of Concrete.
 9. ACI 318, Building Code Requirements for Structural Concrete and Commentary.
 10. ACI 347, Guide to Formwork for Concrete.
 11. ACI 350-06, Code Requirements for Environmental Engineering Concrete Structures.
 12. ACI/CRSI, Adhesive Anchor Installers.
 13. ACI SP-66, ACI Detailing Manual.
 14. ANSI/NSF Standard 61, Drinking Water Systems Components.
 15. ASTM A82, Specification for Steel Wire, Plain, for Concrete Reinforcement.
 16. ASTM A185, Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
 17. ASTM A615, Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 18. ASTM C31, Practice for Making and Curing Concrete Test Specimens in the Field.
 19. ASTM C33, Specification for Concrete Aggregates.
 20. ASTM C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 21. ASTM C94, Specification for Ready-Mixed Concrete.
 22. ASTM C109 – Standard Test Method for Comprehensive Strength of Hydraulic Cement Mortars.
 23. ASTM C138, Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.
 24. ASTM C143, Test Method for Slump of Hydraulic-Cement Concrete.
 25. ASTM C150, Specification for Portland Cement.
 26. ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.
 27. ASTM C172, Practice for Sampling Freshly Mixed Concrete.

28. ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
29. ASTM C260, Specification for Air-Entraining Admixtures for Concrete.
30. ASTM C309, Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
31. ASTM C494, Specification for Chemical Admixtures for Concrete.
32. ASTM C531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing's, and Polymer Concretes.
33. ASTM C579, Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing's, and Polymer Concretes.
34. ASTM C1077, Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.
35. ASTM D638, Standard Test Method for Tensile Properties of Plastics.
36. ASTM D1752, Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
37. ASTM E96, Standard Test Methods for Water Vapor Transmission of Materials.
38. ASTM E1745, Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs.
39. CRD-C 572, U. S. Army Corps of Engineers Specification for Polyvinylchloride Water stops.
40. CRD-C 621, Non-Shrink Grout.
41. CRSI MSP-1, Manual of Standard Practice.
42. ICC-ES AC308, Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

1.3 QUALITY ASSURANCE

- A. Laboratory Trial Batch:
 1. Refer to Section 01 40 00 Quality Requirements.
 2. Owner shall employ third-party testing laboratory experienced in design and testing of concrete materials and mixes to perform material evaluation tests and to design concrete mixes. Contractor to abide by all third-party testing requirements.
 3. Tests on materials used in the production of concrete shall be required as specified in PART 2 -- PRODUCTS. These tests shall be performed by an independent testing laboratory approved by the Engineer.
 4. Trial concrete mixes shall be tested when required in accordance with Article 3.9.
 5. Field quality control tests, as specified in this Section, unless otherwise stated, will be performed by a materials testing consultant employed by the Owner. However, the Contractor shall be charged for the cost of any additional tests and investigation on work performed which does not meet the Specifications. Any individual who samples and tests concrete to determine if the concrete is being produced in accordance with this Specification shall be certified as a Concrete Field Testing Technician, Grade I, in accordance with ACI CP-1 or equivalent. Testing laboratory shall conform to requirements of ASTM C-1077.
 6. Contractor shall provide a sample of reinforcing steel from each delivery if requested by Owner.
 7. Third-party testing is required for each truck delivery unless otherwise directed by Owner.

8. Each concrete mix design specified shall be verified by laboratory trial batch, unless indicated otherwise.
9. Perform the following testing on each trial batch:
 - a. Aggregate gradation for fine and coarse aggregates.
 - b. Slump.
 - c. Air content.
 - d. Compressive strength based on three cylinders each tested at seven days and at 28 days.

B. Field Tests

1. Compression test specimens will be taken during construction from the first placement of each type of grout and at intervals thereafter as selected by the Engineer to ensure continued compliance with these Specifications. The specimens will be made by the Engineer or its representative.
 - a. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C 109 at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days, 28 days and any additional time period as appropriate.
 - b. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C 579, Method B, at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days and any other time as appropriate.
2. The cost of all laboratory tests on grout will be borne by the Owner, but the Contractor shall assist the Engineer in obtaining specimens for testing. The Contractor shall be charged for the cost of any additional tests and investigation on work performed which does not meet the specifications. The Contractor shall supply all materials necessary for fabricating the test specimens, at no additional cost to the Owner.
3. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
 - a. List of concrete materials and concrete mix designs proposed for use. Include results of tests performed to qualify the materials and to establish the mix designs. Do not start laboratory trial batch testing until this submittal is approved by Engineer.
 - b. Concrete placement drawings showing the location and type of all joints.
 - c. Drawings for fabricating, bending, and placing concrete reinforcing. Comply with ACI SP-66. For walls and masonry construction, provide elevations to a minimum scale of 1/4-inch to one foot. Show bar schedules, stirrup spacing, adhesive dowels, splice lengths, diagrams of bent bars, arrangements, and assemblies, as required for fabricating and placing concrete reinforcing.
2. Product Data:
 - a. Manufacturer's specifications with application and installation instructions for proprietary materials and items, including admixtures and bonding agents.

- B. Third-Party Submittals: Submit the following:
1. Laboratory Trial Batch Reports: Submit laboratory test reports for concrete cylinders, materials, and mix design tests.
 2. Project identification name and number (if applicable).
 3. Date of test report.
 4. Complete identification of aggregate source of supply.
 5. Tests of aggregates for compliance with the Contract Documents.
 6. Scale weight of each aggregate.
 7. Absorbed water in each aggregate.
 8. Brand, type, and composition of cementitious materials.
 9. Brand, type, and amount of each admixture.
 10. Amounts of water used in trial mixes.
 11. Proportions of each material per cubic yard.
 12. Gross weight and yield per cubic yard of trial mixtures.
 13. Measured slump.
 14. Measured air content.
 15. Compressive strength developed at seven days and 28 days, from not less than three test cylinders cast for each seven day and 28-day test, and for each design mix.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Section 01 60 00 – Product Requirements.
- B. Transportation, Delivery, and Handling:
1. Deliver concrete reinforcing products to Site bundled, tagged, and marked. Use metal tags indicating bar size, lengths, and other information corresponding to markings on approved Shop Drawings.
 2. Materials used for concrete shall be clean and free from foreign matter during transportation and handling, and kept separate until measured and placed into concrete mixer.
 3. Implement suitable measures during hauling, piling, and handling to ensure that segregation of coarse and fine aggregate particles does not occur and grading is not affected.
 4. Deliver materials from manufacturers in unopened containers that bear intact manufacturer labeling. Inspect packaging for damage before accepting.
- C. Storage:
1. Store materials according to manufacturer instructions.
 2. Store formwork materials above ground on framework or blocking. Cover wood for forms and other accessory materials with protective, waterproof covering. Provide for adequate air circulation or ventilation under cover.
 3. Store concrete reinforcing materials to prevent damage and accumulation of dirt and excessive rust. Store on heavy wood blocking so that reinforcing does not come into contact with the ground. Space framework or blocking supports to prevent excessive deformation of stored materials.
 4. Store concrete joint materials on platforms or in enclosures or covered to prevent contact with ground and exposure to weather and direct sunlight.
 5. For storage of concrete materials, provide bins or platforms with hard, clean surfaces.

- D. Protection:
 - 1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
 - 2. Provide additional protection according to manufacturer instructions.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Admixtures:
 - 1. Air-Entraining Admixture: ASTM C260.
 - 2. Water-Reducing Admixture: ASTM C494, Type A.
 - 3. Water Reducing and Set-Adjusting Admixtures: ASTM C494, Types D and E.
 - 4. High Range Water-Reducing Admixture: ASTM C494, Type F/G.
 - 5. Use only admixtures that have been tested and approved in the mix designs.
 - 6. Do not use calcium chloride or admixtures containing chloride ions.
- B. Aggregates: ASTM C33:
 - 1. Fine Aggregate:
 - a. Washed natural sand.
 - b. Gradation:
 - 1) Comply with ASTM C33.
 - 2) Represented by smooth granulometric curve within required limits.
 - c. Free from injurious amounts of organic impurities according to ASTM C40.
 - 2. Coarse Aggregate:
 - a. Clean, uncoated, processed aggregate containing no clay, mud, loam, or foreign matter.
 - b. Coarse aggregate shall comply with the following:
 - 1) Crushed stone, processed from natural rock or stone.
 - 2) Washed gravel, either natural or crushed. Slag, pit gravel, and bank-run gravel are not allowed.
 - c. Coarse Aggregate Size: ASTM C33, Nos. 57 or 67, unless otherwise approved by Engineer.
- C. Concrete Mix:
 - 1. As specified per manufacturer.
 - 2. Portland Cement, sand, and water.
 - 3. Do not use ferrous aggregate or staining ingredients in grout mixes.
- D. Membrane-Curing Compound Type A:
 - 1. Comply with ASTM C309, Type 1, Class A.
 - 2. Manufacturers:
 - a. Super Diamond Clear VOX by the Euclid Chemical Company.
 - b. MasteKure CC 300 SB by BASF Master Builder Solutions.
 - c. Cure & Seal 30 Plus by Symons Corporation.
 - d. Or equal. As specified in Section 01 60 00 – Product Requirements.
- E. Portland Cement: Comply with ASTM C150/C150M, Type I and II:
 - 1. Minimum 28-day compressive strength of 4,000 psi.

- F. Water: Clean, potable:
 - 1. No impurities, suspended particles, algae, or dissolved natural salts in quantities capable of causing:
 - a. Corrosion of steel
 - b. Volume change increasing shrinkage cracking.
 - c. Efflorescence.
 - d. Excess air entraining.
 - 1) NBEC Grout by Five Star Products, Inc.
 - 2) Or equal. As specified in Section 01 60 00 – Product Requirements.

- G. Epoxy Grout:
 - a. Pre-packaged, non-shrink, non-metallic, 100 percent solids, solvent-free, moisture-insensitive, three-component epoxy grouting system.
 - b. Minimum Seven-day Compressive Strength: 14,000 psi, when tested in accordance with ASTM C579.
 - c. Products and Manufacturers:
 - 1) Euco High Strength Grout, by Euclid Chemical Company.
 - 2) Sikadur 42, Grout Pak, by Sika Corporation.
 - 3) Five Star Epoxy Grout, by Five Star Products, Inc.
 - 4) Or equal. As specified in Section 01 60 00 – Product Requirements.

- H. Grout Fill:
 - a. Grout mix shall consist of cement, fine and coarse aggregates, water, and admixtures complying with requirements specified in this Section for similar materials in concrete.
 - b. Proportion and mix grout fill as follows:
 - 1) Minimum Cement Content: 564 pounds per cubic yard.
 - 2) Maximum Water-Cement Ratio: 0.45.
 - 3) Maximum Coarse Aggregate size: 1/2-inch, unless otherwise indicated.
 - 4) Minimum 28-day Compressive Strength: 4,000 psi.

- I. Rapid-Curing Epoxy Grout:
 - 1. Manufacturers:
 - a. Epoxy Grout
 - 1) Epoxy grout shall be "Sikadur 32 Hi-Mod" by Sika Corporation
 - 2) Duralcrete LV by Tamms Industries.
 - 3) Or equal. As specified in Section 01 60 00 – Product Requirements.
 - 4) Epoxy grout shall be modified as required for each application with aggregate per manufacturer's instructions.
 - 2. Description:
 - a. High-strength, three-component epoxy grout formulated with thermosetting resins and inert fillers.
 - b. Rapid-curing, high adhesion, and resistant to ordinary chemicals, acids, and alkalis.
 - 3. Performance and Design Criteria:
 - a. As specified in the Contract Documents.

- J. REINFORCING MATERIALS
 - 1. Reinforcing Bars: ASTM A615, Grade 60 deformed bars.
 - 2. Welded Wire Fabric: ASTM A185.

3. Steel Wire: ASTM A82.
4. Provide supports for reinforcing including bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing in place.
 - a. Use wire bar-type supports complying with CRSI MSP-1 recommendations, except as specified in this Section. Do not use wood, brick, or other unacceptable materials.
 - b. For slabs on grade, use precast concrete blocks, four inches square minimum with compressive strength equal to or greater than the surrounding concrete, or supports with sand plates or horizontal runners where base materials will not support chair legs.
 - c. For all concrete surfaces where legs of supports are in contact with forms, provide supports having either hot-dip galvanized, plastic-protected, or stainless-steel legs in accordance with CRSI MSP-1.
 - d. Provide precast concrete supports over waterproof membranes.
5. Adhesive Dowels:
 - a. Dowels:
 - 1) Dowel reinforcing bars shall comply with ASTM A615, Grade 60.
 - b. Adhesive:
 - 1) Adhesive requirements in accordance with ICC-ES AC308.

2.2 CONCRETE MIX

- A. General:
 1. Normal weight: 145 pounds per cubic foot.
 2. Use air-entraining admixture in all concrete. Provide not less than four percent, nor more than eight percent, entrained air for concrete exposed to freezing and thawing, and provide from three to five percent entrained air for other concrete.
- B. Proportioning and Design of Class "A" Concrete Mix:
 1. Minimum compressive strength at 28 days: 4,500 psi.
 2. Maximum water-cement ratio by weight: 0.42.
 3. Minimum cement content: 564 pounds per cubic yard.
- C. Proportioning and Design of Class "B" Concrete Mix:
 1. Minimum compressive strength at 28 days: 3,000 psi.
 2. Maximum water-cement ratio by weight: 0.50.
 3. Minimum cement content: 517 pounds per cubic yard.
- D. Slump Limits:
 1. Proportion and design mixes to result in concrete slump at point of placement of not less than one inch and not more than four inches.
 2. When using high-range water reducers, slump prior to addition of admixture shall not exceed three inches. Slump after adding admixture shall not exceed eight inches at point of placement.
- E. Adjustment of Concrete Mixes:
 1. Concrete mix design adjustments may be requested by Contractor when warranted by characteristics of materials, Site conditions, weather, test results, or other, similar circumstances.

2. Submit for Engineer's approval laboratory test data for adjusted concrete mix designs, including compressive strength test results.
3. Implement adjusted mix designs only after Engineer's approval.
4. Adjustments to concrete mix designs shall not result in additional costs to Owner.

2.3 FORM MATERIALS

- A. Provide form materials with sufficient stability to withstand pressure of placed concrete without bow or deflection. Contractor shall be responsible for designing the formwork system to resist all applied loads including pressures from fluid concrete and construction loads.
- B. Smooth Form Surfaces: Acceptable panel-type to provide continuous, straight, smooth, as-cast surfaces in accordance with ACI 301.
- C. Unexposed Concrete Surfaces: Material to suit project conditions.
- D. Provide 3/4-inch chamfer at all external corners. Chamfer is not required at re-entrant corners unless otherwise shown or indicated.
- E. Form Ties:
 1. Provide factory-fabricated, removable, or snap-off metal form ties, that prevent form deflection and prevent spalling of concrete surfaces upon removal. Materials used for tying forms are subject to approval of Engineer.
 2. Unless otherwise shown or indicated, provide ties so that portion remaining within concrete after removal of exterior parts is at least 1.5 inches from outer surface of concrete. Unless otherwise shown or indicated, provide form ties that, upon removal, will leave a uniform, circular hole not larger than one-inch diameter in the concrete surface.
 3. Ties for exterior walls, below-grade walls, and walls subject to hydrostatic pressure shall be provided with water stops.
 4. Wire ties are unacceptable.

2.4 RELATED MATERIALS

- A. Water stops:
 1. All water stops shall comply with ACI 350-06.
 2. Polyvinyl Chloride (PVC) Water stops:
 - a. Manufacturers: Provide products of one of the following:
 - 1) BoMetals, Inc.
 - 2) DuraJoint Concrete Accessories.
 - 3) Sika Greenstreak.
 - 4) Or equal. As specified in Section 01 60 00 – Product Requirements.
 - b. Water stops shall comply with CRD-C 572. Water stop material shall have an off-white, milky color. Water stops shall be manufactured from virgin PVC. Do not use reclaimed or scrap material.
 - c. Minimum Thickness: 3/8-inch.

- d. Provide water stops with minimum of seven ribs equally spaced at each end on each side with the first rib located at the edge. Each rib shall be minimum 1/8-inch in height.
 - e. Construction Joints: Water stops shall be six-inch wide flat-strip type.
 - f. Expansion Joints: Water stops shall be nine-inch wide, ribbed with a center bulb. The center bulb shall have a minimum outside diameter of one-inch and a minimum inside diameter of 1/2-inch.
 - g. The required minimum physical characteristics for this material are:
 - 1) Tensile strength - 1,750 psi (ASTM D-638).
 - 2) Ultimate elongation - not less than 280% (ASTM D-638).
 - h. Contractor shall furnish certification that the proposed water stops meet the above requirements.
 - i. All water stop intersections, both vertical and horizontal, shall be made from factory fabricated corners and transitions. Only straight butt joint splices shall be made in field.
3. Expanding Rubber Water stops:
- a. Expanding rubber shall be designed to expand under hydrostatic conditions. Water stops shall be Adeka Ultra Seal MC-2010M by Adeka Ultra Seal/OCM, Inc., or Hydrotite CJ-1020-2K by Sika Greenstreak, for concrete thickness greater than nine inches. For thicknesses less than nine inches, Adeka Ultra Seal KBA-1510FF or Hydrotite CJ-1020-2K shall be used.
 - b. Water stop shall be a chemically modified natural rubber product with a hydrophilic agent.
 - c. Water stop has a stainless-steel mesh or coextrusion of non-hydrophilic rubber to direct expansion in the thickness direction and restrict the expansion in the longitudinal direction.
4. Hydrophilic Water stops:
- a. Products and Manufacturers:
 - 1) Duroseal Gasket, by BBZ USA, Inc.
 - 2) Adeka Ultraseal MC-2010M, by Asahi Denka Kogyo K.K.
 - 3) Hydrotite, by Greenstreak Plastic Products Company.
 - 4) Or equal. As specified in Section 01 60 00 – Product Requirements.
 - b. Hydrophilic water stop materials shall be bentonite-free and shall expand by minimum of 80 percent of dry volume in the presence of water to form a watertight joint seal without damaging the concrete in which it is cast.
 - c. Water stop material shall be composed of resins and polymers that absorb water and cause a completely reversible and repeatable increase in volume.
 - d. Water stop material shall be dimensionally stable after repeated wet-dry cycles with no deterioration of swelling potential.
 - e. Select material in accordance with manufacturer's recommendations for type of liquid to be contained.
 - f. Minimum cross-sectional dimensions: 3/16-inch by 3/4-inch.
 - g. Location of hydrophilic water stops shall be as shown or indicated on the Drawings, or where approved by Engineer.
 - h. Hydrophilic Sealant: Shall adhere firmly to concrete, metal, and PVC in dry or damp condition and be indefinitely elastic when cured.
 - 1) Products and Manufacturers:
 - i) Duroseal Paste, by BBZ USA, Inc.
 - ii) Adeka Ultraseal P-201, by Asahi Denka Kogyo K.K.
 - iii) Hydrotite, by Greenstreak Plastic Products Company.

- iv) Or equal. As specified in Section 01 60 00 – Product Requirements.
- 5. Water stop Adhesive:
 - a. Adhesive between water stops and existing concrete.
 - 1) Products and Manufacturers:
 - i) 20+F Contact Cement by Miracle Adhesives Corporation
 - ii) Neoprene Adhesive 77-198 by JGF Adhesives
 - iii) Sikadur 31 Hi-Mod Gel by Sika Corporation
 - iv) DP-605 NS Urethane Adhesive by 3M Adhesive Systems.
 - v) Or equal. As specified in Section 01 60 00 – Product Requirements.
 - b. Hydrophilic, non-bentonite water swelling elastic sealant shall be used to bond expanding rubber water stops to rough surfaces.
 - 1) Products and Manufacturers:
 - i) P-201 by Adeka Ultra Seal/OCM, Inc.
 - ii) Leakmaster LV-1 by Sika Greenstreak.
 - iii) Or equal. As specified in Section 01 60 00 – Product Requirements.
- 6. Vapor Retarder:
 - a. Products and Manufacturers:
 - 1) Stego Wrap 10-mil Vapor Retarder, by Stego Industries LLC.
 - 2) Griffolyn 10-mil, by Reef Industries.
 - 3) Moistop Ultra, by Fortifiber Industries.
 - 4) Or equal. As specified in Section 01 60 00 – Product Requirements.
 - b. Vapor retarder membrane shall comply with the following.
 - 1) Water Vapor Transmission Rate, ASTM E96: 0.04 perms or lower.
 - 2) Water Vapor Retarder, ASTM E1745: Meets or exceeds Class C.
 - 3) Thickness of Retarder (plastic), ACI 302 1R: Not less than 10 mils.
 - 4) Provide accessories by same manufacturer as vapor retarder.
- 7. Membrane-Forming Curing Compound: ASTM C309, Type I.
- 8. Epoxy Bonding Agent:
 - a. Two-component epoxy resin bonding agent.
 - b. Products and Manufacturers:
 - 1) Sikadur 32, Hi-Mod LPL, by Sika Corporation.
 - 2) Eucopoxy LPL, by the Euclid Chemical Company.
 - 3) Or equal. As specified in Section 01 60 00 – Product Requirements.
- 9. Epoxy-Cement Bonding Agent:
 - a. Three-component blended epoxy resin-cement bonding agent.
 - b. Products and Manufacturers:
 - 1) Sika Armatec 110 EpoCem, by Sika Corporation.
 - 2) Duralprep A.C., by Euclid Chemical Company.
 - 3) Or equal. As specified in Section 01 60 00 – Product Requirements.
- 10. Preformed Expansion Joint Filler:
 - a. Provide preformed expansion joint filler complying with ASTM D1752, Type I (sponge rubber) or Type II (cork).

PART 3 EXECUTION

3.1 INSPECTION

- A. Contractor shall examine the substrate and the conditions under which the Work will be performed and notify Engineer in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 FORMWORK

- A. Construct formwork in accordance with ACI 347 such that concrete members and structures are of correct size, shape, alignment, elevation, and position.
- B. Provide openings in formwork to accommodate the Work of other trades. Accurately place and securely support items required to be built into formwork.
- C. Clean and adjust forms prior to placing concrete. Apply form release agents or wet forms as required. Re-tighten forms during and after concrete placing, when required, to eliminate cement paste leaks.
- D. Removing Formwork:
 - 1. Comply with ACI 301 and ACI 347, except as otherwise indicated in the Contract Documents.
 - 2. Do not remove formwork and shoring until supported concrete members have acquired minimum of 90 percent of specified compressive strength. Results of suitable quality control tests of field-cured specimens may be submitted to Engineer for review as evidence that concrete has attained sufficient strength for removal of supporting formwork and shoring prior to removal times indicated in the Contract Documents.
 - 3. Removal time for formwork is subject to Engineer's acceptance.
 - 4. Repair form tie-holes following in accordance with ACI 301.

3.3 REINFORCING, JOINTS, AND EMBEDDED ITEMS

- A. Comply with the applicable recommendations of Laws and Regulations and standards referenced in this Section, including CRSI MSP-1, for details and methods of placing and supporting reinforcing.
- B. Clean reinforcing to remove loose rust and mill scale, earth, ice, and other materials which act to reduce or destroy bond between reinforcing material and concrete.
- C. Position, support, and secure reinforcing against displacement during formwork construction and concrete placing. Locate and support reinforcing by means of metal chairs, runners, bolsters, spacers, and hangers, as required.
 - 1. Place reinforcing to obtain minimum concrete coverages as shown on the Drawings and as required in ACI 318. Arrange, space, and securely tie bars and bar supports together with 16-gage wire to hold reinforcing accurately in position during concrete placing. Set with ties so that twisted ends are directed away from exposed concrete surfaces.
 - 2. Do not secure reinforcing to formwork using wire, nails or other ferrous metal. Metal supports subject to corrosion shall not be in contact with formed or exposed concrete surfaces.

- D. Provide sufficient quantity of supports of strength required to carry reinforcing. Do not place reinforcing more than two inches beyond the last leg of continuous bar support. Do not use supports as bases for runways for concrete conveying equipment and similar construction loads.
- E. Splices: Provide standard reinforcing splices by lapping ends, placing bars in contact, and tying tightly with wire. Comply with requirements shown or indicated for minimum lap of spliced bars, as shown on the Drawings or in accordance with the requirements of ACI 318.
- F. Install welded wire fabric in lengths as long as practical, lapping adjoining sections a minimum of one full mesh.
- G. Do not place concrete until reinforcing is inspected and Engineer indicates that conditions are acceptable for placing concrete. Concrete placed in violation of this paragraph will be rejected. Notify Engineer in writing at least two working days prior to proposed concrete placement.
- H. Joints:
 - 1. Provide construction, isolation, expansion, and control joints as indicated or required. Locate construction joints so as to not impair the strength and appearance of the structure. Place isolation and control joints in slabs-on-grade to stabilize differential settlement and random cracking.
 - 2. In mats and structural slabs and beams, locate joints in compliance with ACI 224R.
 - 3. Locations of joints shall be in accordance with the Contract Documents and as approved by Engineer in the Shop Drawings.
 - 4. Where construction joints are indicated to be roughened, intentionally roughen surfaces of previously-placed concrete to amplitude of 1/4-inch.
- I. Installation of Embedded Items:
 - 1. Sleeves, pipe stubs, inserts, anchors, expansion joint material, water stops, and other embedded items shall be positioned accurately and supported against displacement prior to concreting. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.
 - 2. Set and build into the Work anchorage devices and embedded items required for other Work that is attached to, or supported by, cast-in-place concrete. Use setting diagrams, templates, and instructions provided under other Sections and, when applicable, other contracts for locating and setting. Refer to Paragraph 1.1.B of this Section. Do not embed in concrete uncoated aluminum items. Where aluminum items are in contact with concrete surfaces, coat aluminum to prevent direct contact with concrete.
- J. Adhesive Dowels:
 - 1. Where shown on the Drawings, reinforcing bars anchored into hardened concrete with a dowel adhesive system shall use a two-component adhesive mix which shall be injected with a static mixing nozzle following manufacturer's instructions.
 - 2. Determine location of existing reinforcing steel in vicinity of proposed holes prior to drilling. Adjust location of holes to be drilled to avoid drilling through or damaging existing reinforcing bars only when approved by Engineer.

3. All holes shall be drilled in accordance with the manufacturer's instructions except that core drilled holes shall not be permitted unless specifically allowed by the Engineer. Cored holes, if allowed by the manufacturer and approved by the Engineer, shall be roughened in accordance with manufacturer's requirements.
4. Thoroughly clean drill holes of all debris, drill dust, and water in accordance with manufacturer's instructions with compressed air and a wire brush prior to installation of adhesive and reinforcing bar.
5. Degree of hole dampness shall be in strict accordance with manufacturer recommendations. Installation conditions shall be either dry or water-saturated. Water filled or submerged shall not be permitted unless specifically approved by the Engineer.
6. Twist dowels during insertion into partially-filled hole to guarantee full wetting of bar surface with adhesive. Injection of adhesive into the hole shall be performed in a manner to minimize the formation of air pockets in accordance with the manufacturer's instructions.
7. Embedment Depth:
 - a. The embedment depth of the bar shall be as shown on the Drawings. Although all manufacturers listed below are permitted, the embedment depth shown on the Drawings is based on "PE 1000+" by Powers Fasteners. If the Contractor submits one of the other named dowel adhesives from the list below, the Engineer shall evaluate the required embedment and the Contractor shall provide the required embedment depth stipulated by the Engineer specific to the approved dowel adhesive.
 - b. Where the embedment depth is not shown on the Drawings, the embedment depth shall be determined to provide the minimum allowable bond strength equal to the tensile strength of the rebar according to the manufacturer's ICC-ES ESR.
 - c. The embedment depth shall be determined using the actual concrete compressive strength, a cracked concrete state, maximum long-term temperature of 110 degrees F, maximum short-term temperature of 140 degrees F, continuous special inspection of all horizontal and overhead installations, and periodic special inspection of all other installations. In no case shall the embedment depth be less than the minimum, or more than the maximum, embedment depths stated in the manufacturer's ICC-ES ESR.
8. Engineer's approval is required for use of this system in locations other than those shown on the Drawings.
9. The adhesive system shall be IBC compliant for use in both cracked and uncracked concrete in all Seismic Design Categories and shall be:
 - a. Epcon C6+ Adhesive Anchoring System as manufactured by ITW Redhead
 - b. HIT-HY 200 Adhesive Anchoring System as manufactured by Hilti, Inc.
 - c. SET-XP Epoxy Adhesive Anchors as manufactured by Simpson Strong-Tie Co.
 - d. PE-1000+ Epoxy Adhesive Anchor System" by Powers Fasteners.
 - e. Fast-set epoxy formulations shall not be acceptable.
 - f. Or equal. As specified in Section 01 60 00 – Product Requirements.
10. All individuals installing dowel adhesive system shall be certified as an Adhesive Anchor Installer in accordance with the ACI-CRSI Anchor Installation Certification Program.

3.4 CONCRETE PLACING

- A. Site Mixing: Use drum-type batch machine mixer, mixing not less than 1.5 minutes for one cubic yard or smaller capacity. Increase required mixing time by minimum of 15 seconds for each additional cubic yard or fraction thereof.
- B. Ready-Mixed Concrete: Comply with ASTM C94.
- C. Concrete Placing:
 - 1. Prior to placement, all reinforcement shall be secured.
 - 2. Place concrete in a continuous operation within planned joints or sections in accordance with ACI 304R.
 - 3. Do not begin placing concrete until work of other trades affecting concrete is completed.
 - 4. Wet concrete and subgrade surfaces to saturated surface dry condition immediately prior to placing concrete.
 - 5. Deposit concrete as near its final location as practical to avoid segregation due to re-handling or flowing.
 - 6. Avoid separation of the concrete mixture during transportation and placing. Concrete shall not free-fall for distance greater than four feet during placing.
 - 7. Complete concrete placing within 90 minutes of addition of water to the dry ingredients.
- D. Consolidate placed concrete in accordance with ACI 309R using mechanical vibrating equipment supplemented with hand rodding and tamping, such that concrete is worked around placing and other embedded items and into all parts of formwork. Insert and withdraw vibrators vertically at uniformly-spaced locations. Do not use vibrators to transport concrete within the formwork. Vibration of formwork or placing is not allowed.
- E. Protect concrete from physical damage or reduced strength due to weather extremes during mixing, placing, and curing.
 - 1. In hot weather comply with ACI 305R.
 - 2. In cold weather comply with ACI 306R.

3.5 QUALITY OF CONCRETE WORK

- A. Make concrete solid, compact, smooth, and free of laitance, cracks, and cold joints.
- B. Concrete for liquid-retaining structures and concrete in contact with earth, water, or exposed directly to the elements shall be watertight.
- C. Cut out and properly replace to extent directed by Engineer, or repair to satisfaction of Engineer, surfaces that contain cracks or voids, are unduly rough, or are in defective in any way. Patches or plastering are unacceptable.
- D. Repair, removal and replacement of defective concrete directed by Engineer shall be at no additional cost to Owner.

3.6 CONCRETE CURING

- A. Use of curing compound:
 - 1. Curing compound should be applied as per manufacturer's recommendations.

2. Curing compound shall be used only where specifically approved by the Engineer. Curing compound shall never be used for curing exposed walls with fluid or earth backfill on the opposite side. A continuous wet cure for a minimum of five days is required for these applications. Curing compound shall not be used on surfaces exposed to water in potable water storage tanks and treatment plants unless curing compound is certified in accordance with ANSI/NSF Standard 61.
3. When permitted, the curing compound shall maintain the concrete in a moist condition for the required time period, and the subsequent appearance of the concrete surface shall not be affected.
4. The compound shall be applied in accordance with the manufacturer's recommendations after water sheen has disappeared from the concrete surface and after finishing operations. Maximum coverage for the curing and sealing compound shall be 300 square feet per gallon for trowel finishes and 200 square feet per gallon for floated or broom surfaces. Maximum coverage for compounds placed where subsequent finishes will be applied shall be 200 square feet per gallon. For rough surfaces, apply in two directions at right angles to each other.

B. Protection and Curing.

1. All freshly placed concrete shall be protected from the elements, flowing water and from defacement of any nature during construction operations.
2. As soon as the concrete has been placed and horizontal top surfaces have received their required finish, provision shall be made for maintaining the concrete in a moist condition for at least a 5-day period thereafter except for high early strength concrete, for which the period shall be at least the first three days after placement. Horizontal surfaces shall be kept covered, and intermittent, localized drying will not be permitted.
 - a. Walls that will be exposed on one side with either fluid or earth backfill on the opposite side shall be continuously wet cured for a minimum of five days. Use of a curing compound will not be acceptable for applications of this type.
3. The Contractor shall use one of the following methods to ensure that the concrete remains in a moist condition for the minimum period stated above.
 - a. Ponding or continuous fogging or sprinkling.
 - b. Application of mats or fabric kept continuously wet.
 - c. Continuous application of steam (under 150°F).
 - d. Application of sheet materials conforming to ASTM C171.
 - e. Other means as approved by the Engineer.
4. The Contractor shall keep absorbent wood forms wet until they are removed. After form removal, the concrete shall be cured by one of the methods in paragraph D.
5. Any of the curing procedures used in Article 3.6 may be replaced by one of the other curing procedures listed in Article 3.6 after the concrete is one-day old. However, the concrete surface shall not be permitted to become dry at any time.

C. Curing Concrete Under Cold Weather Conditions

1. Suitable means shall be provided for a minimum of 72 hours after placing concrete to maintain it at or above the minimum as placed temperatures specified in this Section, for concrete work in cold weather. During the 72-hour period, the concrete surface shall not be exposed to air more than 20°F above the minimum as placed temperatures.
2. Stripping time for forms and supports shall be increased as necessary to allow for retardation in concrete strength caused by colder temperatures. This retardation is

magnified when using concrete made with blended cements or containing fly ash or ground granulated blast furnace slag. Therefore, curing times and stripping times shall be further increased as necessary when using these types of concrete.

3. The methods of protecting the concrete shall be approved by the Engineer and shall be such as will prevent local drying. Equipment and materials approved for this purpose shall be on the site in sufficient quantity before the work begins. The Contractor shall assist the Engineer by providing holes in the forms and the concrete in which thermometers can be placed to determine the adequacy of heating and protection. All such thermometers shall be furnished by the Contractor in quantity and type which the Engineer directs.
4. Curing procedures during cold weather conditions shall conform to the requirements of ACI 306.

D. Curing Concrete Under Hot Weather Conditions.

1. When air temperatures exceed 85°F, the Contractor shall take extra care in placing and finishing techniques to avoid formation of cold joints and plastic shrinkage cracking. If ordered by the Engineer, temporary sun shades and/or windbreakers shall be erected to guard against such developments, including generous use of wet burlap coverings and fog sprays to prevent drying out of the exposed concrete surfaces.
2. Immediately after screeding, horizontal surfaces shall receive an application of evaporation reducer. Apply in accordance with manufacturer's instructions. Final finish work shall begin as soon as the mix has stiffened sufficiently to support the workmen.
3. Curing and protection of the concrete shall begin immediately after completion of the finishing operation. Continuous moist-curing consisting of method a or b listed in paragraph 3.6.A.3 is mandatory for at least the first 24 hours. Method 2 may be used only if the finished surface is not marred or blemished during contact with the coverings.
4. At the end of the initial 24-hour period, curing and protection of the concrete shall continue for at least six (6) additional days using one of the following methods:
 - a. Ponding or continuous fogging or sprinkling.
 - b. Application of mats or fabric kept continuously wet.
 - c. Continuous application of steam (under 150°F).
 - d. Application of sheet materials conforming to ASTM C171.
 - e. Other means as approved by the Engineer.
5. Curing procedures during hot weather conditions shall conform to the requirements of ACI 305.

E. Use of Curing Compound

1. Curing compound shall be used only where specifically approved by the Engineer. Curing compound shall never be used for curing exposed walls with fluid or earth backfill on the opposite side. A continuous wet cure for a minimum of five days is required for these applications. Curing compound shall not be used on surfaces exposed to water in potable water storage tanks and treatment plants unless curing compound is certified in accordance with ANSI/NSF Standard 61.
2. When permitted, the curing compound shall maintain the concrete in a moist condition for the required time period, and the subsequent appearance of the concrete surface shall not be affected.

3. The compound shall be applied in accordance with the manufacturer's recommendations after water sheen has disappeared from the concrete surface and after finishing operations. Maximum coverage for the curing and sealing compound shall be 300 square feet per gallon for trowel finishes and 200 square feet per gallon for floated or broom surfaces. Maximum coverage for compounds placed where subsequent finishes will be applied shall be 200 square feet per gallon. For rough surfaces, apply in two directions at right angles to each other.

F. Early Termination of Curing

1. Moisture retention measures may be terminated earlier than the specified times only when at least one of the following conditions is met:
 - a. The strength of the concrete reaches 85 percent of the specified 28-day compressive strength in laboratory-cured cylinders representative of the concrete in place, and the temperature of the in-place concrete has been constantly maintained at 50 degrees Fahrenheit or higher.
 - b. The strength of concrete reaches the specified 28-day compressive strength as determined by accepted nondestructive methods or laboratory-cured cylinder test results.

3.7 FINISHING

A. Finishes on Formed Concrete Surfaces:

1. After removal of forms, the finishes described below shall be applied in accordance with this Article. Unless the finish schedule specifies otherwise, all surfaces shall receive at least a Type I finish. The Engineer shall be the sole judge of acceptability of all concrete finish work.
 - a. Type I - Rough: All fins, burrs, offsets, marks and all other projections left by the forms shall be removed. Projections, depressions, etc. below finished grade required to be removed will only be those greater than 1/4-inch. All holes left by removal of ends of ties, and all other holes, depressions, bugholes, air/blow holes or voids shall be filled solid with cement grout after first being thoroughly wetted and then struck off flush. The only holes below grade to be filled will be tie holes and any other holes larger than 1/4-inch in any dimension. Honeycombs shall be chipped back to solid concrete and repaired as directed by the Engineer. All holes shall be filled with tools, such as sponge floats and trowels, that will permit packing the hole solidly with cement grout. Cement grout shall consist of one-part cement to three parts sand, epoxy bonding agent (for tie holes only) and the amount of mixing water shall be as little as consistent with the requirements of handling and placing. Color of cement grout shall match the adjacent wall surface.
 - b. Type II - Grout Cleaned: Where this finish is required, it shall be applied after completion of Type I finish. After the concrete has been predampened, a slurry consisting of one-part cement (including an appropriate quantity of white cement in order to produce a color matching the surrounding concrete) and 1-1/2 parts sand passing the No. 16 sieve, by damp loose volume, shall be spread over the surface with clean burlap pads or sponge rubber floats. Mix proportions shall be submitted to the Engineer after a sample of the work is established and accepted. Any surplus shall be removed by scraping and then rubbing with clean burlap.

- c. Type III - Smooth Rubbed: Where this finish is required, it shall be applied after the completion of the Type II finish. No rubbing shall be done before the concrete is thoroughly hardened and the mortar used for patching is firmly set. A smooth, uniform surface shall be obtained by wetting the surface and rubbing it with a carborundum stone to eliminate irregularities. Unless the nature of the irregularities requires it, the general surface of the concrete shall not be cut into. Corners and edges shall be slightly rounded by the use of the carborundum stone. Brush finishing or painting with grout or neat cement will not be permitted. A 100 square foot example shall be established at the beginning of the project to establish acceptability. Apply chemical floor hardener to exposed interior concrete floor areas when cured and dry, in accordance with hardener manufacturer's instructions.

B. Slab and Floor Finishes:

1. The finishes described below shall be applied to floors, slabs, flow channels and top of walls in accordance with this Article. The Engineer shall be the sole judge of acceptability of all such finish work.
 - a. Type "A" – Screeded: This finish shall be obtained by placing screeds at frequent intervals and striking off to the surface elevation required. When a Type "F" finish is subsequently to be applied, the surface of the screeded concrete shall be roughened with a concrete rake to 1/2" minimum deep grooves prior to final set.
 - b. Type "B" – Wood or Magnesium Floated: This finish shall be obtained after completion of a Type "A" finish by working a previously screeded surface with a wood or magnesium float or until the desired texture is reached. Floating shall begin when the water sheen has disappeared and when the concrete has sufficiently hardened so that a person's foot leaves only a slight imprint. If wet spots occur, water shall be removed with a squeegee. Care shall be taken to prevent the formation of laitance and excess water on the finished surface. All edges shall be edged with a 1/8-inch tool as directed by the Engineer. The finished surface shall be true, even, and free from blemishes and any other irregularities.
 - c. Type "C" – Cork Floated: This finish shall be similar to Type "B" but slightly smoother than that obtained with a wood float. It shall be obtained by power or band floating with cork floats.
 - d. Type "D" – Steel Troweled: This finish shall be obtained after completion of a Type "B" finish. When the concrete has hardened sufficiently to prevent excess fine material from working to the surface, the surface shall be compacted and smoothed with not less than two thorough and complete steel troweling operations. In areas which are to receive a floor covering such as tile, resilient flooring, or carpeting, the applicable Specification Sections and Contract Drawings shall be reviewed for the required finishes and degree of flatness. In areas that are intermittently wet such as pump rooms, only one troweling operation is required to provide some trowel marks for slip resistance. All edges shall be edged with a 1/8-inch tool as directed by the Engineer. The finish shall be brought to a smooth, dense surface, free from defects and blemishes.
 - e. Type "E" – Broom or Belt: This finish shall provide the surface with a transverse scored texture by drawing a broom or burlap belt across the surface immediately after completion of a Type "B" finish. All edges shall be

edged with a 1/8-inch tool as directed by the Engineer. Type "F" - Swept in Grout Topping: This finish shall be applied after a completion of a Type "A" finish. The concrete surface shall be properly cleaned, washed, and coated with a mixture of water and Portland Cement. Cement grout in accordance with this Section shall then be plowed and swept into neat conformance with the blades or arms of the apparatus by turning or rotating the previously positioned mechanical equipment. Special attention shall be paid to true grades, shapes and tolerances as specified by the manufacturer of the equipment. Before beginning this finish, the Contractor shall notify the Engineer and the equipment manufacturer of the details of the operation and obtain approval and recommendations.

- f. Type "F" – Swept in Grout Topping: This finish shall be applied after a completion of a Type "A" finish. The concrete surface shall be properly cleaned, washed, and coated with a mixture of water and Portland Cement. Cement grout in accordance with this Section shall then be plowed and swept into neat conformance with the blades or arms of the apparatus by turning or rotating the previously positioned mechanical equipment. Special attention shall be paid to true grades, shapes and tolerances as specified by the manufacturer of the equipment. Before beginning this finish, the Contractor shall notify the Engineer and the equipment manufacturer of the details of the operation and obtain approval and recommendations.
- g. Type "G" – Hardened Finish: This finish shall be applied after completion of a Type "B" or Type "C" finish and prior to application of a Type "D" finish. Hardeners shall be applied in strict accordance with the manufacturer's requirements. Hardeners shall be applied using a mechanical spreader. The hardener shall be applied in two shakes with the first shake comprising 2/3 of the total amount. Type "D" finish shall be applied following completion of application of the hardener.
 - 1) Non-metallic floor hardener shall be applied where specifically required on the Contract Drawings at the rate of 1.0 pounds/ft².
 - 2) Non-oxidizing heavy duty metallic floor hardener shall be applied at the loading docks and where specifically required on the Contract Drawings or specified herein at the rate of 1.5 pounds/ft².
- h. Type "H" – Non-Slip Finish: This finish shall be provided by applying a non-slip flooring additive concurrently with the application of a Type "D" finish and/or installation of floor sealants. Application procedure shall be in accordance with manufacturer's instructions. Finish shall be applied where specifically required on the Contract Drawings or specified herein
- i. Type "J" – Raked Finish: This finish shall be provided by raking the surface as soon as the condition of the concrete permits by making depressions of ± 1/4 inch.

C. Concrete Sealers:

- 1. Concrete sealers shall be applied where specifically required on the Contract Drawings or specified herein.
- 2. Sealers shall be applied after installation of all equipment, piping, etc. and after completion of any other related construction activities. Application of sealers shall be in strict accordance with manufacturer's requirements.
- 3. Sealers shall be applied to all floor slabs not painted and not intended to be immersed.

4. Floor slabs subjected to vehicular traffic shall be sealed with the concrete liquid densifier and sealer.
 5. All other floor slabs to receive sealer shall be sealed with concrete floor sealer.
- D. Finishes on Equipment Pads:
1. Formed surfaces of equipment pads shall receive a Type III finish.
 2. Top surfaces of equipment pads, except those surfaces subsequently required to receive grout and support equipment bases, shall receive a Type "D" finish, unless otherwise noted. Surfaces which will later receive grout shall, before the concrete takes its final set, be made rough by removing the sand and cement that accumulates on the top to the extent that the aggregate will be exposed with irregular indentations in the surface up to 1/2 inch deep.

3.8 GROUT PLACING

A. General:

1. The different types of grout shall be used for the applications stated below unless noted otherwise in the Contract Documents. Where grout is called for in the Contract Documents which does not fall under any of the applications stated below, non-shrink grout shall be used unless another type is specifically referenced.
 - a. Cement grout shall be used for grout toppings and for patching of fresh concrete.
 - b. Non-shrink grout shall be used for grouting beneath base plates of structural metal framing. Dry-packing is not allowed, unless otherwise indicated.
 - c. Epoxy grout shall be used for bonding new concrete to hardened concrete.
 - d. Epoxy base plate grout shall be used for precision seating of base plates including base plates for all equipment such as engines, mixers, pumps, vibratory and heavy impact machinery, etc.
2. New concrete surfaces to receive cement grout shall be as specified in this Section and shall be cleaned of all dirt, grease and oil-like films. Existing concrete surfaces shall likewise be cleaned of all similar contamination and debris, including chipping or roughening the surface if a laitance or poor concrete is evident. The finish of the grout surface shall match that of the adjacent concrete.
3. All mixing, surface preparation, handling, placing, consolidation, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.
4. The Contractor, through the manufacturer of a non-shrink grout and epoxy grout, shall provide on-site technical assistance upon request, at no additional cost to the Owner.

B. Consistency:

1. The consistency of grouts shall be that necessary to completely fill the space to be grouted for the particular application. Dry pack consistency is such that the grout is plastic and moldable but will not flow.

C. Measurement of Ingredients:

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

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

D. Grout Installation:

1. General:

- a. The different types of grout shall be used for the applications stated below unless noted otherwise in the Contract Documents. Where grout is called for in the Contract Documents which does not fall under any of the applications stated below, non-shrink grout shall be used unless another type is specifically referenced.
 - 1) Cement grout shall be used for grout toppings and for patching of fresh concrete.
 - 2) Non-shrink grout shall be used for grouting beneath base plates of structural metal framing.
 - 3) Epoxy grout shall be used for bonding new concrete to hardened concrete.
 - 4) Epoxy base plate grout shall be used for precision seating of base plates including base plates for all equipment such as engines, mixers, pumps, vibratory and heavy impact machinery, etc.
- b. New concrete surfaces to receive cement grout shall be as specified in this Section and shall be cleaned of all dirt, grease and oil-like films. Existing concrete surfaces shall likewise be cleaned of all similar contamination and debris, including chipping or roughening the surface if a laitance or poor concrete is evident. The finish of the grout surface shall match that of the adjacent concrete. Curing and protection of cement grout shall be as specified in this Section.
- c. All mixing, surface preparation, handling, placing, consolidation, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.
- d. The Contractor, through the manufacturer of a non-shrink grout and epoxy grout, shall provide on-site technical assistance upon request, at no additional cost to the Owner.

2. Formwork:

- a. Construct leakproof forms anchored and shored to withstand grout pressures.
- b. Install formwork with clearances to permit proper placement of grout.
- c. As specified in this Section.

3. Mixing:

- a. All mixing, surface preparation, handling, placing, and consolidation shall be completed according to the manufacturer's recommendations.

4. Placing of Grout:

- a. Grout shall be placed quickly and continuously, shall completely fill the space to be grouted and be thoroughly compacted and free of air pockets.
- b. The grout may be poured in place, pressure grouted by gravity, or pumped.
- c. The use of pneumatic pressure or dry-packed grouting requires approval of the Engineer.
- d. For grouting beneath base plates, grout shall be poured from one side only and thence flow across to the open side to avoid air-entrapment.

5. Curing:

- a. Prevent rapid loss of water from grout during first 48 hours by use of approved membrane curing compound or by using wet burlap method.

- b. Immediately after placement, protect grout from premature drying, excessively hot or cold temperatures, and mechanical injury.
- c. After grout has attained its initial set, keep damp for minimum three days.

3.9 FIELD QUALITY CONTROL

- A. Site Testing Services:
 - 1. Owner shall employ independent testing laboratory to perform field quality control testing for concrete. Engineer will direct where samples are obtained.
 - 2. Testing laboratory will provide all labor, material, and equipment required for sampling and testing concrete, including: scale, glass tray, cones, rods, molds, air tester, thermometer, and other incidentals required.
- B. Inspection and Testing of Grout:
 - 1. Comply with ACI 318 and as specified in Section 01 40 00 – Quality Requirements.
 - 2. Tests of grout components may be performed to ensure compliance with specified requirements.
- C. Quality Control Testing During Construction:
 - 1. Field Testing of Concrete
 - a. The Contractor shall coordinate with the Engineer's project representative the on-site scheduling of the materials testing consultant personnel as required for concrete testing.
 - b. Concrete for testing shall be supplied by the Contractor at no additional cost to the Owner, and the Contractor shall provide assistance to the materials testing consultant in obtaining samples. The Contractor shall dispose of and clean up all excess material.
 - 2. Consistency
 - a. The consistency of the concrete will be checked by the materials testing consultant by standard slump cone tests. The Contractor shall make any necessary adjustments in the mix as the Engineer and/or the materials testing consultant may direct and shall upon written order suspend all placing operations in the event the consistency does not meet the intent of the specifications. No payment shall be made for any delays, material or labor costs due to such eventualities.
 - b. Slump tests shall be made in accordance with ASTM C143. Slump tests will be performed as deemed necessary by the materials testing consultant and each time compressive strength samples are taken.
 - c. Concrete with a specified nominal slump shall be placed having a slump within 1" (higher or lower) of the specified slump. Concrete with a specified maximum slump shall be placed having a slump less than the specified slump.
 - 3. Unit Weight
 - a. Samples of freshly mixed concrete shall be tested for unit weight by the materials testing consultant in accordance with ASTM C138.
 - b. Unit weight tests will be performed as deemed necessary by the Engineer and each time compressive strength samples are taken.
 - 4. Air Content
 - a. Samples of freshly mixed concrete will be tested for entrained air content by the materials testing consultant in accordance with ASTM C231.

- b. Air content tests will be performed as deemed necessary by the materials testing consultant and each time compressive strength samples are taken.
 - c. In the event test results are outside the limits specified, additional testing shall occur. Admixture quantity adjustments shall be made immediately upon discovery of incorrect air entrainment.
5. Compressive Strength
- a. Samples of freshly mixed concrete will be taken by the materials testing consultant and tested for compressive strength in accordance with ASTM C172, C31, and C39, except as modified herein.
 - b. In general, one sampling shall be taken for each placement in excess of five (5) cubic yards, with a minimum of one (1) sampling for each day of concrete placement operations, or for each one hundred (100) cubic yards of concrete, or for each 5,000 square feet of surface area for slabs or walls, whichever is greater.
 - c. Each sampling shall consist of at least five (5) 6x12 cylinders or (8) 4x8 cylinders. Each cylinder shall be identified by a tag, which shall be hooked or wired to the side of the container. The materials testing consultant will fill out the required information on the tag, and the Contractor shall satisfy himself that such information shown is correct.
 - d. The Contractor shall be required to furnish labor to the Owner for assisting in preparing test cylinders for testing. The Contractor shall provide approved curing boxes for storage of cylinders on site. The insulated curing box shall be of sufficient size and strength to contain all the specimens made in any four consecutive working days and to protect the specimens from falling over, being jarred or otherwise disturbed during the period of initial curing. The box shall be erected, furnished and maintained by the Contractor. Such box shall be equipped to provide the moisture and to regulate the temperature necessary to maintain the proper curing conditions required by ASTM C31. Such box shall be located in an area free from vibration such as pile driving and traffic of all kinds and such that all specimen are shielded from direct sunlight and/or radiant heating sources. No concrete requiring inspection shall be delivered to the site until such storage curing box has been provided. Specimens shall remain undisturbed in the curing box until ready for delivery to the testing laboratory but not less than sixteen hours.
 - e. The Contractor shall be responsible for maintaining the temperatures of the curing box during the initial curing of test specimens with the temperature preserved between 60°F and 80°F as measured by a maximum-minimum thermometer. The Contractor shall maintain a written record of curing box temperatures for each day curing box contains test specimens. Temperature shall be recorded a minimum of three times a day with one recording at the start of the work day and one recording at the end of the work day.
 - f. When transported, the cylinders shall not be thrown, dropped, allowed to roll, or be damaged in any way.
 - g. Compression tests shall be performed in accordance with ASTM C39. For 6x12 cylinders, two test cylinders will be tested at seven days and two at 28 days. For 4x8 cylinders, three test cylinders will be tested at seven days, three at 28 days. The remaining cylinders will be held to verify test results, if needed.
6. When ordered by the Engineer, additional tests shall be provided and paid for by the Contractor.

END OF SECTION