SECTION 03 3000
CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of contract, including General and Supplementary Conditions and Division 1 specification sections apply to the work of this section.

1.02 WORK INCLUDED

A. Extent of work is shown on the Drawings, including schedules, notes and details which show size and location of members and type of concrete to be poured.

B. Furnish all labor, material and equipment necessary for and incidental to the completion of all concrete work. Concrete work includes, but is not necessarily limited to, the following:

1. Formwork, complete with required shoring, reshoring, temporary bracing and anchorage.
2. Concrete reinforcing including welded wire fabric, complete with required supports, spacers and related accessories.
3. Placing anchors, plates, and inserts required for attachment and/or support of structural and/or architectural precast concrete, structural steel or other materials and furnished under other specifications.
4. Cast-in-place concrete.
5. Finish and cure of floor slabs and toppings.
6. Grouting of elevator sills and leveling plates.
7. Vapor barrier and granular base below interior slabs-on-grade.
8. Grouting under base plates and bearing plates.
9. Miscellaneous concrete work such as equipment bases, splash pads, and under floor duct encasement. All as shown on M.E.P. Drawings.
10. Concrete inspection and testing. (Quality Control)
11. Expansion bolts in concrete.
12. Adhesive bolts in concrete.
13. Polystyrene Board Filler.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Division 2 - Excavation, Grading and Backfill

B. Division 2 - Concrete Curbs and Sidewalks.

C. Division 2 - Paving and Surfacing: Concrete paving.

D. Division 3 - Architectural Concrete Work.

E. Division 3 - Architectural Precast Concrete.

F. Division 4 - Masonry: Reinforced Masonry.

G. Division 5 - Structural Steel: Furnishing anchor bolts and leveling plates for structural steel. Setting and grouting of base and bearing plates.

H. Division 5 - Miscellaneous Metals: Sleeves, anchors, inserts and other embedded items to be cast in

concrete.

I. Division 7 - Fluid Applied Waterproofing.

J. Division 7 - Concrete Penetrating Sealer: Application of concrete penetrating sealer on surfaces.

K. Division 15, Division 16: Coordinating sizes and locations of mechanical & electrical equipment pads and bases.

L. Division 15, Division 16: Providing and installing sleeves, inserts and anchors specified for mechanical and electrical items.

M. Division 15, Division 16: Concrete encasement of electrical conduits and site utilities.

1.04 REFERENCES

A. The Work under this section shall be subject to all applicable provisions of the state and local building and safety codes and other codes and standards referenced in this specification.

B. Comply with the American Concrete Institute "Standard Specifications for Structural Concrete," ACI 301, unless amended or superseded by requirements of this section or General Notes on structural drawings.

C. In case of conflict among documents, including architectural and structural drawings and specifications, notify the Architect prior to submitting proposal. In case of conflict between the structural drawings and specifications, the strictest interpretation shall govern. All references shall be latest editions.

1. ACI 233R – Slag Cement in Concrete and Mortar.
2. ACI 301 – Specifications for Structural Concrete.
3. ACI 303 – Standard Specification for Cast-in-Place Architectural Concrete.
4. ACI 304R – Guide for Measuring, Mixing, Transporting, and Placing Concrete.
5. ACI 304.2R – Placing Concrete by Pumping Methods.
6. ACI 305.1 – Specification for Hot Weather Concreting.
7. ACI 306.1 – Standard Specification for Cold Weather Concreting.
8. ACI 309R – Guide for Consolidation of Concrete.
9. ACI SP-15 – ACI Field Reference Manual: Specifications for Structural Concrete for Buildings with Selected ACI and ASTM References. Contractor shall provide at least one copy of this publication available in the field office all times.
10. ACI SP-66 – ACI Detailing Manual.
11. ASTM A153 – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
12. ASTM A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength.
13. ASTM A615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
14. ASTM A706 – Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement.
15. ASTM A1064 – Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
16. ASTM C33 – Standard Specification for Concrete Aggregates.
17. ASTM C42 – Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
18. ASTM C94 – Standard Specification for Ready-Mixed Concrete.
19. ASTM C150 – Standard Specification for Portland Cement.
20. ASTM C171 – Standard Specification for Sheet Materials for Curing Concrete.
21. ASTM C227 – Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate

Combinations (Mortar-Bar Method).
22. ASTM C260 – Standard Specification for Air-Entraining Admixtures for Concrete.
23. ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
24. ASTM C330 – Standard Specification for Lightweight Aggregates for Structural Concrete.
25. ASTM C494 – Standard Specification for Chemical Admixtures for Concrete.
26. ASTM C578 – Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
27. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
28. ASTM C827 – Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures.
29. ASTM C881 – Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
30. ASTM C942 – Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
31. ASTM C989 – Standard Specification for Slag Cement for Use in Concrete and Mortars.
32. ASTM C1116 – Standard Specification for Fiber-Reinforced Concrete.
33. ASTM C1240 – Standard Specification for Silica Fume Used in Cementitious Mixtures.
34. ASTM C1550 – Standard Test Method for Flexural Toughness of Fiber Reinforced Concrete (Using Centrally Loaded Round Panel).
35. ASTM C1579 – Standard Test Method for Evaluating Plastic Shrinkage Cracking of Restrained Fiber Reinforced Concrete (Using a Steel Form Insert).
36. ASTM C1602 – Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
37. ASTM C1609 – Standard Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading).
38. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12400 ft-lbf/ft^3 (600 kN-m/m^3)).
39. ASTM D1751 – Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types).
40. ASTM E154 - Standard Test Methods for Water Vapor Retarders used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover.
41. "Manual of Standard Practice," Concrete Reinforcing Steel Institute (CRSI), latest edition.
42. AASHTO T318: “Standard Method of Test for Water Content of Freshly Mixed Concrete Using the Microwave Oven".

1.05 QUALITY CONTROL

A. The Contractor is responsible for quality control, including workmanship and materials furnished by his subcontractors and suppliers.

1. Inspection or testing by the Owner does not relieve the Contractor of his responsibility to perform the Work in accordance with the Contract Documents.
2. Workmanship: The Contractor is responsible and shall bear the cost of correcting concrete work which does not conform to the specified requirements, including, but not limited to, strength, tolerances, and finishes. Correct deficient concrete by means acceptable to the Architect. The cost of extra work incurred by the Architect to approve corrective work shall be borne by the Contractor.

1.06 QUALITY ASSURANCE

A. Owner will engage a qualified Testing Agency, approved by the Architect and Engineer to perform tests and inspections required by these specifications. Testing Agency shall comply with ASTM E329 and shall furnish a certificate of compliance, signed by the Professional Engineer responsible for management of the Agency. The Professional Engineer must be registered in the state where the project is located. Testing and inspection include the following:

1. Inspect formwork, reinforcing and concrete in conformance with the special inspection requirements of the IBC. Keep records and submit reports indicated.
    a. Testing to verify the adequacy of work done without prior notice, or contrary to standard construction practice.
2. Concrete testing will be performed in accordance with the requirements of ACI 301 and as modified below:
    a. Mold and cure four (4) specimens from each sample. Specimens shall be 6” x 12” cylinders.
    b. Compressive strength tests: One set of specimens for each 100 cubic yards or fraction thereof of each concrete class placed in any one day; one specimen tested at seven (7) days, two specimens tested at 28 days, and one specimen held in reserve.
    c. Concrete Temperature: Test hourly when air temperature is below 40 degrees F. and each time a set of specimens is made.
    d. Determine and report slump of each sample.
3. All concrete batch trip tickets will be collected and retained by the Contractor. Compressive and slump tests shall be identified by reference to a particular trip ticket. Concrete batch trip tickets shall contain information specified in ASTM C94; Paragraph entitled "Batch Ticket Information". The ticket shall also clearly show the amount of water for the entire batch which may be added in the field that will not exceed the water cement ratio specified by the design mix. The Architect/Engineer and Contractor will be immediately notified of trip tickets not as specified herein.
    a. The Architect/Engineer and Contractor will be immediately notified when the amount of water in a batch of concrete exceeds that allowed in the design mix.
4. Additional Tests for Concrete Work:
    a. The Independent Testing Agency will make additional tests of in-place concrete work as directed by the Architect/Engineer when test results indicate that specified concrete strengths and other characteristics have not been attained in the structure. The Independent Testing Laboratory will conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42. Costs of such tests will be borne by the Owner if test results indicate conformance with the Contract Documents. Such tests indicating nonconformance with the Contract Documents will be paid by the Contractor including additional architectural and engineering services made necessary by such nonconformance.
    b. The strength of the structure in place will be considered to be potentially deficient if it fails to comply with any requirement which controls the strength of the structure.
    c. The cost of any additional tests, including load tests and/or other nondestructive tests directed by the Architect/Engineer or conducted by the Contractor to prove the adequacy of the concrete work, shall be borne by the Contractor including additional architectural and engineering services made necessary by such tests.
    d. Inspections or testing performed exclusively for the Contractor's convenience shall be the sole responsibility of the Contractor.
5. Miscellaneous requirements:
    a. The Architect and Independent Testing Agency shall have uninterrupted access to the ready-mix batching plant at all times that the work is in progress.
    b. Provide the Testing Agency with the following;
        1) Incidental labor required to facilitate testing.
        2) Minimum one day's advance notice when concrete is to be placed.
        3) Storage facilities for concrete test cylinders.
        4) Materials, samples, and access to materials as required for testing.
    c. Reimbursement of costs for testing and inspection resulting as a consequence of the following:
        1) Work not in compliance with the Contract Documents.
        2) Testing requested by the Contractor or Subcontractor such as additional cylinders for early breaks, etc.
        3) Testing to verify the adequacy of work done without prior notice, or contrary to

standard construction practice.

d. Record of Work: A record shall be kept by the General Contractor listing the time and date of placement of all concrete for the structure. Such record shall be kept until the completion of the project and shall be available to the Architect/Engineer for examination at any time.

B. See Division 1, "Special Inspection."

C. Surveys:

1. The Owner will employ a licensed Surveyor to monitor as-built line and level conditions. Line and level surveys will be performed for each level before formwork is removed and immediately after formwork has been removed.
   a. Surveys shall report plan locations of all horizontal concrete edges and shall report deviations from plumb for all concrete rises. Surveys shall also report actual elevations at each level at all columns and actual elevations at centerline of all bays before and after form removal.
   b. Nonconforming work will be rejected.
   c. Owner's survey of as-built concrete structure shall in no way relieve Contractor of responsibility to provide concrete work within specified tolerances capable of accepting all subsequent work.

1.07 SUBMITTALS

A. Submit Shop Drawings, Product Data, Mix Designs, and Samples in accordance with the following:

1. Submit (1) electronic copy of each shop drawing. Reproducible copies of contract documents shall not be used as shop drawings. Shop drawings shall be reviewed by Contractor prior to submission. Drawings shall bear Contractor's approval stamp accepting responsibility for coordination of dimensions shown in the contract documents, quantities and coordination with other trades. Drawings not bearing contractors stamp may be rejected at the discretion of the Architect or Structural Engineer. Electronic copy will be returned with Architect’s and/or Engineer’s comments. Allow 14 calendar days in the Structural Engineers office for review of shop drawings.
2. Provide (1) electronic copy of mix design & product data. Electronic copy will be returned following review by the Architect/Engineer.

B. Mix Designs

1. Submit substantiating data for each proposed concrete mix design to the Architect/Engineer not less than 3 weeks prior to first concrete placement. Data for each mix shall, as a minimum, include the following:
   a. Mix identification designation (unique for each mix submitted).
   b. Statement of intended use for mix.
   c. Mix proportions, including all admixtures used.
   d. Product data and/or certifications verifying conformance of all mix materials, including admixtures, with specified requirements.
   e. Wet and dry unit weight.
   f. Entrained air content.
   g. Design slump or spread (Self-Consolidating Conrete).
   h. Required average strength qualification data per ACI 301 4.2.3.2 and 4.2.3.3 including back up test data. Submit separate qualification data for each production facility which will supply concrete to the project.
   i. Field test data submitted under h. above shall include copies of the Concrete Testing Agency's reports from which the data was compiled.
   j. Submit one copy of a representative concrete batch trip ticket.

2. Separate design mixes are required for each strength and class of concrete, each change in type and/or quantity of mix materials including admixtures, each change in slump limits, and each change in entrained air content.
3. For concrete placed by pumping, separate mix designs are required for each 100 feet of vertical or horizontal distance from the pump to the point of discharge. This requirement may be waived if evidence acceptable to the Architect is submitted demonstrating, by previous successful experience, that the proposed mix will meet all requirements of these specifications, when sampled at the point of discharge, over the full range of distances required.

C. Submit Product Data with application and installation instructions for proprietary materials and items including reinforcement and forming accessories, admixtures, patching compounds, epoxies, grouts, dry-shake finish material, hardeners, sealers, waterstops, joint systems and others as required by the Architect.

D. Submit Shop Drawings for fabrication, bending and placement of concrete reinforcement. Comply with ACI Detailing Manual (SP 66). Provide 1/8"=1<0" scale elevations of all walls with reinforcing shown. Include special reinforcement required at openings through concrete structure. Include all accessories specified and required to support reinforcement. Obtain from General Contractor location of proposed constructions joints and indicate on the shop drawings.

E. Submit samples of concrete materials if requested by the Architect, including trade names, sources, and descriptions.

F. Submit curing compound product data and verification of its acceptable compatibility with type of concrete penetrating sealer and waterproofing and other subsequent architectural surface treatments.

G. Submit materials certificates, mill test reports, and materials laboratory test reports, if requested by the Architect, attesting that each material item complies with or exceeds the specified requirements.

H. Submit shop drawings, by the precast supplier, locating all embedded plates furnished by and required in the cast-in-place concrete to support precast members.

1.08 DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials: Deliver materials (except bulk materials) in manufacturer's unopened containers fully identified with manufacturer's name, trade name, type, class, grade, size, and color.

B. Storage of Materials: Store materials in unopened containers. Store off ground and under cover, protected from damage.

C. Reinforcing: Unload and store reinforcing bars so they will be kept free of mud. Store on wood skids while awaiting use.

D. Concrete: See "Production and Delivery of Concrete" section under PART 2 of these specifications.

PART 2 PRODUCTS

2.01 CONCRETE FORMS

A. Form Materials: Comply with ACI 301 as supplemented and modified in this Section.

1. Formwork and formwork systems for formed structural floors and roofs shall be designed by a Professional Engineer employed by the Contractor. The Professional Engineer shall be registered in the state where the project is located. The Contractor shall submit written certification indicating conformance with this requirement.

B. Cylindrical Columns and Supports: Form round section members with paper or fiber tubes, constructed of laminated plies using water-resistant type adhesive with wax-impregnated exterior for weather and moisture protection. Provide units with sufficient wall thickness to resist deformation due to loads imposed by wet concrete.

C. Earth cuts may be used as forms for wall footings below finish grade when soil conditions are acceptable to the Architect/Engineer.

D. Forms for Unexposed Finish Concrete: Unless otherwise specified, formwork for unexposed concrete surfaces shall be constructed with plywood, lumber, metal or other suitable material. Lumber shall be dressed on at least two edges and one side for tight fit.

E. Form Coatings: Provide commercial formulation form-coating compounds that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.02 REINFORCEMENT

A. Reinforcing Steel Bars:

1. ASTM A615, Grade 60, except as noted otherwise on drawings. Welding reinforcing bars not permitted except where specifically indicated.

2. All reinforcing required to be welded shall conform to ASTM A-706, Grade 60.

B. Welded Wire Fabric: Mesh size and gauge as indicated on the Drawings. Conform to ASTM A1064, plain finish, in flat sheets.

C. Wire: Smooth wire for spiral reinforcement shall conform to the "Standard Specification for Steel Wire, Plain, for Concrete Reinforcement, " ASTM A1064, with a minimum yield strength of 70,000 PSI.

D. Tie Wire: Tie wire shall be annealed steel tie wire, minimum 16 gauge.

E. Supports for Reinforcement: Provide supports for reinforcement including bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcement in place, in accordance with the recommendations of the Concrete Reinforcing Steel Institute as modified below.

1. Use supports with sand plates or horizontal runners where base material will not support chair legs for slab-on-grade.
2. For exposed-to-view concrete surfaces: Provide supports with legs plastic tipped, where legs of supports contact forms.
3. All materials that come in direct contact with epoxy coated bars, such as slab bolsters, high chairs, tie wires, etc., shall be plastic coated.
4. Provide accessories and supports for welded wire fabric and reinforcement in composite concrete slabs as required.

2.03 CONCRETE MATERIALS

A. Portland Cement: ASTM C150, Type I or Type II. Type III may be used if acceptable to the Architect. Use only one manufacturer and type of cement throughout the Project.

1. Alkali Content: Maximum 0.6 percent, or certify that no alkali reactivity is produced with the proposed cement-aggregate combinations when tested in accordance with ASTM C227.

B. Supplementary Cementitious Materials:

1. Fly Ash: ASTM C618, Class C or F.
2. Slag Cement: ASTM C989, Grade 100 or 120
3. Silica Fume: ASTM C1240. Products:
    a. “MasterLife SF 100” by BASF Corporation.
    b. Eucon MSA by The Euclid Chemical Company
    c. Approved equal.
4. Metakaolin: ASTM C618, Class N. Products:
    a. “MetaMax” by BASF Kaolin (part of BASF Corporation).
    b. Approved equal.

C. Aggregates: Provide aggregates in conformance to ACI 301 and ASTM C33. Provide aggregates from same source and supplier as used in the concrete mix design.

1. Pea Gravel: Washed clean, hard, rounded gravel conforming to ASTM C33 except graded for 90% passing the 3/8 inch screen and 90% retained on the 1/4 inch screen. Use pea gravel only when acceptable to the Architect/Engineer.

D. Water: ASTM C1602. Potable.

E. Admixtures:

1. General:
    a. Admixtures Containing Chloride Ions: Admixtures containing intentionally-added chloride ions shall not be used in prestressed concrete, concrete containing galvanized or aluminum embedments, concrete containing high-early strength cement (Type III), concrete on metal deck floors or roofs, or concrete exposed to sulfate containing solutions such as soils with a water soluble sulfate content more than 0.20 percent by weight and all water with a sulfate content more than 1500 parts per million.
    b. The maximum chloride ion content for corrosion protection in concrete at an age of 28 days, contributed from ingredients including water, aggregates, cementitious materials and admixtures shall be as follows:
        1) Prestressed concrete = 0.06% by weight of cement.
        2) Reinforced concrete which may be exposed to chloride in service = 0.015% by weight of cement.
        3) Reinforced concrete that will be dry or protected from moisture in service = 1.00% by weight of cement.
        4) All other reinforced concrete = 0.30% by weight of cement.
    c. The addition of calcium chloride or admixtures containing intentionally-added chloride ions is not permitted.
    d. Certification: Written conformance to the specified requirements and the chloride ion content will be required from the admixture manufacturer prior to mix design review by the Architect.
2. Water Reducing Admixture: ASTM C494, Type A (water reducing-normal set), or Type D (water reducing and retarding admixture) containing no chloride ions intentionally added during manufacture.
    a. "Eucon WR-91" by the Euclid Chemical Co.
    b. "Plastocrete 161" by Sika Chemical Corporation.
    c. "Polyheed" Series by BASF Corporation.
3. High Range Water Reducing Admixture (Super Plasticizer): ASTM C494, Type F or G (Super Plasticizer with retarder).
    a. "Eucon 37" or Plastol Series by the Euclid Chemical Co.

b. "Sikament" by Sika Chemical Corporation.
c. “MasterRheobuild 1000”, “MasterGlenium” Series or “PS 1466” by BASF Corporation.

4. Non-chloride Accelerator Admixture: ASTM C494, Type C (Accelerating only) or E (Water reducing and accelerating admixture).
   a. "Accelguard 80, 90, or G3" by the Euclid Chemical Co.
   b. "Daraccel" by W. R. Grace & Co.
   c. “MasterSet AC 534” or “MasterSet FP 20” by BASF Corporation.
5. Retarding Admixture: ASTM C494, Type B (Retarding only) or D (Water reducing and retarding admixture).
   a. “MasterSet R” Series or “MasterSet DELVO” Series by BASF Corporation.
   b. Approved equal.
6. Workability-Retaining Admixture: ASTM C494, Type S. Shall retain concrete workability without affecting time of setting or early age strength development.
   a. “MasterSure Z-60” by BASF Corporation.
   b. Eucon Retarder Series by The Euclid Chemical Company.
   c. Approved equal.
7. Permeability-Reducing Admixture: ASTM C494, Type S.
   a. “MasterLife 300D” by BASFCorporation.
   b. Vandex AM-10 by The Euclid Chemical Company.
   c. Approved equal.
8. Corrosion-Inhibiting Admixture: Shall be a nominal 30 percent solution of calcium nitrite or amine/ester-based organic corrosion-inhibiting admixture.
   a. “MasterLife CI 30” or “MasterLife CI 222” by BASF Corporation.
   b. Eucon CIA or Eucon BCN by The Euclid Chemical Company.
   c. Approved equal.
9. Shrinkage-Reducing Admixture: ASTM C494, Type S.
   a. “MasterLife SRA 20” or “MasterLife CRA 007” by BASF Corporation.
   b. Conex or Eucon SRA Series by The Euclid Chemical Company.
   c. Approved equal.
10. Alkali-Silica Reaction Inhibiting Admixture: ASTM C494, Type S. Shall contain a nominal lithium nitrate content of 30 percent.
    a. “MasterLife ASR 30” by BASF Corporation.
    b. Eucon Integral ARC by The Euclid Chemical Company.
    c. Approved equal.
11. Coloring Admixture:
    a. “MasterColor” by BASF Corporation.
    b. Increte Color System by The Euclid Chemical Company.
    c. Approved equal.
12. Air Entraining Admixture: ASTM C260. Comply with ACI 301 for all concrete used for vehicular traffic and parking or concrete permanently exposed to the weather.
    a. “MasterAir” Series by BASF Corporation.
    b. Eucon Air Mix Series by The Euclid Chemical Company.
    c. Approved equal.

F. Fibers:

1. Micro Synthetic Fibers:
   a. Shall conform to ASTM C1116.
   b. Shall provide a minimum crack reduction ratio (CRR) of [40%] when tested in accordance with ASTM C1579.
   c. Products and Manufacturers:
      i. “MasterFiber F or M” Series by BASF Corporation.
      ii. Fiberstrand Series by The Euclid Chemical Company.
      iii. Approved equal.

2. Macro Synthetic Fibers:
   a. Structural fibers shall be a coarse monofilament, self-fibrillating, polypropylene / polyethylene to blend in accordance with ASTM C1116, Paragraph 4.1.3, Type III. Structural fiber shall have a minimum tensile strength of 73 to 80 ksi, minimum length of 1.5 inches.
   b. The dosage shall be 4 lbs/cy or higher as required to achieve a minimum equivalent flexural strength (Fe3) of [200 psi] when measured in accordance with ASTM C1609. "Test Method for Flexural Performance of Fiber Reinforced Concrete (Using Beam with Third Point Loading.)"
   c. Products and Manufacturers:
      i. "MasterFiber MAC" by BASF Corporation.
      ii. Tuf-Strand SF by The Euclid Chemical Company.
      iii. Approved equal.

3. Polymer Repair Mortar: These patching mortars may be used when color match of the adjacent concrete is not required. Prior approval by the Engineer is required.
   a. Verticoat and Overhead Repairs
      i. EucoRepair V100, Verticoat or Verticoat Supreme by The Euclid Chemical Company.
      ii. Sikatop 123 by Sika Corp.
      iii. Approved equal.
   b. Horizontal Repairs
      i. Thin Top Supreme, or Concrete Top Supreme by The Euclid Chemical Company.
      ii. Sikatop 121 or Sikatop 122 by Sika Corp.
      iii. Approved equal.

4. Repair Underlayment: Free flowing, self-leveling, pumpable cementitious base compound. Provide the following:
   a. EucoFloor SL 160 or Tammspatch II by The Euclid Chemical Company.
   b. Approved equal.

2.04 LIGHTWEIGHT CONCRETE

A. Maximum Dry Unit Weight of Lightweight Concrete: 115 ±4 pcf at 28 days.

B. Lightweight aggregates conforming to ASTM C-330 "Standard Specification for Lightweight Aggregates for Structural Concrete".

2.05 JOINTS AND EMBEDDED ITEMS

A. Pre-molded compressible joint fillers.

1. Fiber Joint Filler: Conform to ASTM D1751. See plans for location and thickness.

B. Embedded Items:

1. Embedded items shall not displace reinforcing bars.
2. Rated or specified capacity of embedded items shall not be construed as the design capacity of the supporting concrete members.
3. Adjustable wedge insert: Malleable cast iron, complete with bolts, nuts, and washers; 3/4 inch bolt diameter unless otherwise shown.
4. Threaded inserts: Malleable cast iron with full depth bolts; 3/4 inch diameter unless otherwise shown.
5. Steel Plates, Bars and Structural Shapes: Conform to ASTM A36.
6. Special use proprietary products proposed by the Contractor will be considered. Submit test data, manufacturer's data, placement instructions, and other pertinent data for approval by the

Architect.

2.06 NONSHRINK GROUT

A. Provide premixed, non-shrink, non-corrosive, non-metallic, non-staining product containing selected silica sands, Portland Cement, and water-reducing agents. The product shall require only the addition of water and shall comply with the requirements of ASTM C1107.

1. Minimum compressive strength, when tested according to ASTM C-942 with manufacturer's maximum allowable water content: 3000 psi after one day; 7000 psi after 28 days.
2. Grout shall be free of gas-producing or air-releasing agents and oxidizing agents.
3. Grout shall contain no corrosive iron, aluminum, or gypsum.
4. Grout shall be placed at a fluid consistency and shall exhibit no visible bleeding two hours after placement and totally non-shrink in 28 days in accordance with ASTM C-827 with manufacturer's maximum water content.
5. Do not vibrate the grout.
6. Acceptable Manufacturers and Products:
   a. BASF Corporation “MasterFlow 100”.
   b. Burke by Edoco "Burke Non-Ferrous Non-Shrink Grout".
   c. L&M Chemicals "Crystex".
   d. Euclid Chemical Company "NS Grout" or Hi-Flow Grout.
   e. Or approved equal.

2.07 RELATED MATERIALS

A. Form Release Agent: Nox-Crete form coating or equal product acceptable to the Architect/Engineer which will not impair the bonding characteristics of surface-applied materials.

B. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.

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

1. Waterproof paper
2. Polyethylene film
3. Polyethylene-coated burlap.

D. Curing Compounds: Liquid-type, membrane-forming curing compound, conforming to requirements of ASTM C309. Use Type I, Class A, compounds. Curing compounds should not be used on surfaces that are to receive additional concrete, paint, tile, or other material requiring a positive bond, unless the Contractor has demonstrated that the membrane can be satisfactorily removed before the subsequent application is made, or the membrane can serve satisfactorily as the base for the later application.

1. MasterKure CC 180WB manufactured by BASF Corporation.
2. Super Rez-Seal manufactured by the Euclid Chemical Co.
3. Dress and Seal manufactured by L&M Construction Chemicals, Inc.

E. Bonding and Adhesive Compounds:

1. Bonding Compound: Polyvinyl acetate type, rewettable.
   a. Tammsweld, SBR Latex or AKKRO-7T manufactured by Euclid Chemical Co.
   b. Everbond by L&M Construction Products, Inc.
2. Epoxy Products: Two component material suitable for use on dry or damp surface, complying with ASTM C-881, for use in all structural concrete repairs.
   a. Products for Crack Repair:

1) Dural Injection Series by The Euclid Chemical Company
2) "Sikadur 35 Hi Mod LV"; Sika Corporation
3) "MasterInject 1500"; BASF Corporation

b. Products for Epoxy Mortar Patches:
1) Dural 452 Series by The Euclid Chemical Company
2) "Sikadur 21 Lo-Mod LV"; Sika Corporation
3) "MasterEmaco ADH 1090RS"; BASF Corporation

c. Products for Epoxying Bolts or Reinforcing Steel into Concrete:
1) Dural Fast Set Epoxy Gel by The Euclid Chemical Company
2) "Sikadur 31 Hi-Mod Gel"; Sika Corporation
3) "MasterEmaco ADH 327RS"; BASF Corporation

d. Products for Epoxying Steel Plates to Concrete:
1) Dural Epoxy Gel by The Euclid Chemical Company
2) "Sikadur 31 Hi-Mod Gel"; Sika Corporation
3) "MasterEmaco ADH 327RS"; BASF Corporation

e. Substitutions may be considered provided complete technical information and job references are furnished to the Architect/Engineer for approval prior to commencement of work.

F. Nonskid Aggregate Finish: Provide fused aluminum oxide grits or crushed emery, as abrasive aggregate for nonslip finish with emery aggregate containing not less than 40% aluminum oxide and not less than 25% ferric oxide. Use material that is factory-graded, packaged, rustproof and non-glazing, and is unaffected by freezing, moisture and cleaning materials. Locations for nonskid finish are per Architectural Drawings.

G. Sheet Vapor Retarder: ASTM E 1745, Class A, minimum 15 mils thickness, except with maximum water-vapor permeance of 0.01 perms. Include manufacturer's recommended adhesive or pressure-sensitive tape.

1. Products: Subject to compliance with requirements, provide one of the following:
i. Fortifiber Building Systems Group; Moistop Ultra 15.
ii. Insulation Solutions, Inc.; Viper VaporCheck II 15 mil.
iii. Meadows, W. R., Inc.; Perminator 15 mil.
iv. Raven Industries Inc.; Vaporblock VB15.
v. Reef Industries, Inc.; Griffolyn 15 mil Green.
vi. Stego Industries, LLC; Stego Wrap 15 mil Class A.
vii. Poly-America; Husky Yellow Guard 15 mil Class A.

H. Curing and Hardening Compound: Sodium Silicate Compound. These products should be used for remedial curing and hardening subject to review by the Architect/Engineer.

1. Eucosil by Euclid Chemical Co.
2. Chem Hard by L&M Construction Chemicals.
3. MasterKure HD 100WB by BASF Corporation.

I. Expansion Bolts in Concrete:

1. ICBO Approval: Only concrete anchors approved by the International Conference of Building Officials (ICBO) with a published Research Report shall be approved for use.
2. All anchors shall be installed in strict accordance with Manufacturer's printed installation instructions (MPII) in conjunction with edge distance, spacing and embedment depth as indicated on the drawings.
3. The contractor shall arrange for a Manufacturer's field representative to provide installation training for all products to be used, prior to commencement of work. Only trained installers shall perform post-installed anchor installation. A record of training shall be kept on site and be made available to the EOR/Inspector as requested.

4. Type: All expansion bolts in concrete shall be wedge type expansion bolts.
   a. Interior Use: All expansion bolts, nuts, and washers for use in interior conditioned environments free of potential moisture shall be manufactured from carbon steel zinc plated in accordance with Federal Specification QQ-Z-325.
   b. Exterior or Exposed Use: All expansion bolts, nuts, and washers for use in exposed or potentially wet environments, or for attachment of exterior cladding materials, shall be galvanized or stainless steel. Stainless steel bolts shall be manufactured from 300 series stainless steel, and nuts and washers from 300 series or Type 18-8 stainless steel.
   c. Nuts and Washers: Nuts and washers shall be furnished by the manufacturer and used with the bolts.
5. Acceptable Products and Manufacturers:
   a. "Kwik-Bolt"; Hilti
   b. "Power-Stud+"; Powers Fasteners
   c. "Trubolt"; ITW Ramset/Red Head
   d. Other manufacturers will be acceptable only if approved by ICBO with an ICBO Research Report submitted for Engineer review.

J. Adhesive Anchors in Concrete:

1. Type: Adhesive anchors in concrete shall consist of a threaded steel rod meeting the minimum requirements of ASTM A36 or A307 and a sealed glass, tube or sausage type capsule containing polyester resin, quartz sand aggregate and a hardener.
   a. Interior Use: For use in environments free of potential moisture anchors shall be manufactured from carbon steel zinc plated in accordance with Federal Specification QQ-Z-325.
   b. Exterior or Exposed Use: Adhesive anchors used in exterior, exposed, or potentially wet environments, and for attachment of exterior cladding materials, shall have threaded rods manufactured from ASTM A153 galvanized steel or 300 series stainless steel. Nuts and washers shall also be galvanized or stainless steel.
2. Adhesive anchors installed in horizontal to vertically overhead orientation to support sustained tension loads shall be done by a certified Adhesive Anchor Installer (AAI) as certified through ACI/CRSI (ACI 318-11 D.9.2.2). Proof of current certification shall be submitted to the engineer for approval prior to commencement of installation.
3. Adhesive anchors must be installed in concrete aged a minimum of 21 days (ACI 318-11 D.2.2).
4. Nuts and Washers shall be furnished by the manufacturer and used with the anchors.
5. Acceptable Products:
   a. “HVA Adhesive Anchor”; Hilti Fastening Systems
   b. “Chem-Stud Adhesive Anchor”; Power Fasteners
   b. Other manufacturers will be acceptable only if approved by ICBO with an ICBO Research Report submitted for Engineer review.

K. Granular base below slabs on grade: clean well graded, free draining, crushed aggregate, free from all deleterious substances, including clay, dirt, lumps, organic topsoil, frozen material, etc.

L. Extruded Polystyrene Board Filler: Rigid cellular thermal insulation with closed cells and integral high density skin, formed by the expansion of polystyrene base resin in an extrusion process complying with ASTM C578 for type indicated; CFC free and as follows:

1. Type IV, 1.6 lbs/cu. ft. minimum density, unless noted otherwise.

2.08 CONCRETE PROPORTIONING AND DESIGN OF MIXES

A. Proportion ingredients and design concrete mixes in accordance with ACI 301, Section 4.2.3, as modified in this Section.

B. Fly Ash: A maximum of 20% by weight of the cement may be replaced with fly ash at the ratio of one pound of fly ash for every one pound of cement removed.

C. Slag Cement: A maximum by weight of the cement may be replaced with slag cement at the ratio of one pound of slag cement for every pound of cement removed.

D. Durability:

1. All concrete exposed to exterior or the potential of freezing temperatures, including concrete paving, shall be air-entrained with 5% to 7% entrained and entrapped air.
2. All concrete subjected to deicers shall have a maximum water-cement ratio of 0.40.

E. Admixtures:

1. All concrete shall contain water-reducing or high-range water-reducing admixture (superplasticizer).
2. Hot weather conditions: When temperatures exceed 85 degrees F., and/or placing conditions require retardation of the setting time, the Architect/Engineer may require a change from water reducing admixture Type A (normal) admixture to Type D (retarding) formulation of the water-reducing admixture.
3. Cold weather conditions: Concrete for slabs placed when the temperature is below 50 degrees F., may include a noncorrosive accelerator conforming to ASTM C494, Type C or E. Manufacturer shall submit long-term test data proving the noncorrosive effects on galvanized steel deck and reinforcement before use. Submit certification from steel deck manufacturer that deck warranty is not affected by the use of the proposed accelerator.
4. Use high range water reducing admixture in pumped concrete, architectural concrete, concrete for heavy use industrial slabs, self-consolidating concrete, parking structure slabs, concrete required to be watertight and concrete with a water cementitious materials ratio below 0.50.
5. Use a non-corrosive accelerator in all concrete less than 8 inches in thickness, placed at temperatures below 50 degrees Fahrenheit. Do not use calcium chloride, salts or other admixtures containing more than 0.05% chloride ions by weight.

F. Maximum slumps before addition of superplasticizer shall be as follows:

1. Pumped lightweight concrete 5-1/2"
2. All other structural concrete 4".

G. Selection of Proportions of Ingredients:

1. Prepare design mixes for each type of concrete used in the construction. Use an Independent Testing Laboratory acceptable to the Architect/Engineer for design, preparation and reporting proposed mix designs.
   a. Proportion mixes to obtain compressive strengths indicated on the Drawings.
   b. Where compressive strength is not indicated, assume minimum 4000 psi 28-day strength.
2. Document that proposed mix designs will produce required average strength, f_{cr}, by one of the following:
   a. Method 1: Field test data. ACI 301, 4.2.3.4 (a) except that field records shall be for the same mix design proposed and interpolation between records is not allowed.
   b. Method 2: Trial mixtures; ACI 301, 4.2.3.4 (c)
   c. Method 3: Modify ACI 301, 4.2.3.4 (c) as follows: Prepare at least 3 trial batches, one each for slumps of 5", 7" and 9" (tolerance: minus 0", plus 1/2") with cement content held constant and variable quantities of water. Plot compression test results versus slump and water cement ratio. Select mix design with highest water content meeting required average strength, f'_c. Adjust cement content, redesign and retest until contractor is satisfied with workability at required average strength, f_{cr}.

d. Use Method 2 or 3 for mix designs with fly ash or lightweight aggregate.

3. The mix selected shall have the highest water content that will produce the specified required strength plus 1200 psi.
4. Cement content and water may be modified by the Independent Testing Laboratory in redesign and testing of the mix until the specified strength plus 1200 psi is obtained with workability to satisfy the Contractor.
5. If the batch plant has adequate documentation acceptable to the Architect/Engineer showing standard deviation in concrete strengths of less than 600 psi, the design strength of the mix may be reduced to less than 1200 psi over that called for on the Drawings per ACI 301.
6. Slag cement mix shall be designed in accordance with guidelines in ACI 233R-95.
7. Use materials from the same source from start to finish of Project unless changes have been accepted by the Architect/Engineer.
8. Adjustment of Concrete Mixes: Concrete mix design adjustments may be requested by the Contractor when characteristics of materials, project conditions, weather, test results, or other circumstances warrant.
   a. Laboratory test reports for revised mix designs and strength results shall be submitted to the Architect/Engineer and reviewed before use of revised concrete mixes in the Work.
9. Shrinkage: All mix designs shall have a maximum shrinkage of 0.04% @ 28 days, as measured in accordance with ASTM C157 modified, 7-day moist cure. Lower shrinkage requirements shall be shown on the plans.

2.09 FILLED STAIR TREADS AND LANDINGS

A. One (1) part cement to one (1) part sand to two (2) parts pea gravel, 3/8 inch maximum size.

2.10 PRODUCTION AND DELIVERY OF CONCRETE

A. Produce and deliver concrete in accordance with ACI 301 and as modified in this Section. Produce and deliver concrete during hot and cold weather in accordance with the recommendations of ACI 305.1 and ACI 306.1.

B. Ready-Mixed Concrete:

1. Concrete will be considered unacceptable if under any climatic conditions it undergoes initial set or if not deposited within 90 minutes of the time water is introduced, whichever comes first.
2. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter maximum discharge time is required. The concrete will be considered unacceptable if not deposited within 75 minutes after the introduction of mixing water to the cement or aggregate or the introduction of cement to the aggregate when air temperature is between 80 degrees F. and 90 degrees F., and within 60 minutes when air temperature is above 90 degrees F.
5. Just prior to discharging concrete, mix each load of concrete a minimum of 70 revolutions of mixer drum at full mixing speed.

PART 3 EXECUTION

3.01 GENERAL

A. Perform work in accordance with the International Building Code and other applicable requirements of governing authorities having jurisdiction.

B. Perform concrete work in accordance with "Specifications for Structural Concrete," ACI 301, as modified in this Section.

C. Granular material below slabs on grade: Compact to 98% of maximum dry density per ASTM D698. Spread in even layers and compact with rolling equipment.

3.02 FORMWORK

A. Design, construct, brace and maintain formwork in accordance with ACI 301 and the recommendations of ACI 347 as modified in this Section.

B. Preparation of Form Surfaces:

1. Clean reused forms of concrete matrix residue, repair and patch as required to return forms to acceptable surface condition.
2. Coat contract surfaces of forms with a form-coating compound before reinforcement is placed.
3. Thin form-coating compounds only with thinning agent of type, and in amount, and under conditions of form-coating compound manufacturer's instructions. Do not allow excess form-coating material to accumulate in forms or to come into contact with concrete surfaces against which fresh concrete will be placed. Apply in compliance with manufacturer's instructions.
4. Coat steel forms with a non-staining, rust-preventative form oil or otherwise protect against rusting. Rust stained steel formwork is not acceptable.

C. Construction Joints: Locate and install construction joints as indicated on the Drawings or, if not shown on Drawings, located so as not to impair strength and appearance of the structure, as acceptable to Architect/Engineer.

1. Provide 1-1/2" minimum depth continuous keyways at all construction joints lacking continuous reinforcing through the joint and as shown on the Drawings. Preformed metal keyways or wood fabrications are acceptable.

D. Isolation Joints in Slabs-on-Grade: Construct isolation joints (without dowels) in slabs-on-ground at points of contact between slabs-on-ground and vertical surfaces only where specifically detailed on the drawings. Provide construction joints with dowels at all locations unless isolation joints are detailed.

1. Joint filler and sealant materials are specified elsewhere in these specifications.

E. Control (Contraction) Joints in Slabs-on-Grade: Jointing: Construct control joints in slabs on grade using pre-molded key joints, inserts, tooled joints or saw cuts with a minimum depth of one inch. Do not use saw cuts for exterior concrete work.

1. Where control joint spacing is not indicated on the Drawings, space joints at maximum 20 feet.
2. Control joints shall be saw cut. Cutting should commence before drying or cooling causes random cracking. Cut sawed joints as soon as the surface is dry to the touch and the cut does not spall or un-ravel, but no later than 8 hours after concrete placement.
3. Maximum spacing of construction joint for slabs-on-grade: No limit. Joint sealant material if required is specified elsewhere in these specifications.

F. Provide blocking and shoring as required to prevent deformation and damage to steel deck [and steel slab forms] during placement and curing of concrete fill. Locate C.J. where acceptable to the Architect/Engineer.

G. Miscellaneous:

1. Chamfer Strips (ACI 303): [Install 45 degree chamfer strips at exposed outside corners.] [Install radius chamfer strips at exposed outside corners.] [Install chamfer strips at internal corners and edges of formed joints as detailed on Architectural drawings.]

2. Rustication Strips: Securely nail within the forms using finish nails.

3.03 INSTALLATION OF EMBEDDED ITEMS

A. Reinforcing Steel:

1. Install reinforcing in proper position according to the tolerances given in ACI 301.
2. Maintain reinforcing in proper position during concrete placement operations.
3. Handling of epoxy-coated bars: All systems for handling coated bars shall have padded contact areas. All bundling bands shall be padded.
4. Reinforcement partially embedded in concrete shall not be field bent except as shown on the drawings or specifically permitted by the Architect/Engineer.

B. Other Embedded Items:

1. Coordinate work with requirements of mechanical and electrical installations and accommodations. Do not install sleeves in any concrete slabs, beams, walls, or columns except where shown on the drawings or upon written approval by the Architect/Engineer.
2. Cooperate and coordinate the requirements for installation of embedded items specified and furnished in other sections of the specifications. Obtain templates and instructions for setting embedded items.
3. Anchors, inserts, blockouts, anchor bolts, and other items built into the concrete shall be securely fastened to formwork or held in place with appropriate devices. Insertion into concrete after pouring will not be allowed.
4. Dovetail Slots: Install in formwork whenever masonry abuts concrete such as brick ledges, or surfaces to receive masonry veneer, intersections of masonry walls with concrete walls or columns. See Division 4 for requirements.
5. Tolerance for anchor bolts and other embedded items:
   a. 1/8-inch center-to-center of any two bolts within an anchor bolt group where an anchor bolt group is defined as the set of anchor bolts which receive a single fabricated steel shipping piece.
   b. 1/4-inch center-to-center of adjacent anchor bolt groups.
   c. Maximum accumulation of 1/4-inch per hundred feet along the established column line of multiple anchor bolt groups, but not to exceed a total of 1 inch, where the established column line is the actual field line most representative of the centers of the as-built anchor bolt groups along the line of columns.
   d. 1/4-inch from the center of any anchor bolt group to the established column line through that group.
   e. Unless shown otherwise, anchor bolts are set perpendicular to the theoretical bearing surface.
   f. Other embedded items or connection material furnished by others for embedment in concrete shall be set in accordance with the tolerance requirements of the AISC Code of Standard Practice for Steel Buildings and Bridges.
6. Tolerance for embedded plates required to support precast members:
   a. Vertical location 1/2"
   b. Horizontal location 3/4"
   c. Plates must be securely attached to the forms to ensure they will not move during concrete placing operations.

C. Vapor Barrier: Install over prepared base material at slabs-on-grade.

3.04 CONCRETE PLACEMENT

A. Preplacement Inspection: Inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast-in. Do not place concrete until the Work has been reviewed by the Owner's Testing Agency

B. Miscellaneous:

1. Do not place concrete in free-standing water, over ice, or on frozen subgrade.
2. Twenty-four hours must elapse between adjacent slab and wall placement. Columns and walls must reach an initial set (minimum three (3) hours curing) before framing supported thereon is placed.

C. Conveying:

1. Convey concrete from the mixer to point of deposit without segregation and so as to maintain continuous plastic flow at delivery and until the casting unit is complete.

D. Placing: Comply with ACI 301 and 304 as modified in this section.

1. Wet exposed subgrade, masonry filler units, precast concrete, previously placed concrete, and uncoated wood forms immediately prior to placing concrete (except during freezing temperatures).
2. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as herein specified. Deposit concrete as nearly as practicable in its final location to avoid segregation.
3. Placing Concrete in Forms: Deposit concrete in forms in horizontal layers no deeper than 24" and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints.
4. Guide the flow of concrete in walls and columns for vertical drop between the reinforcing. Free fall, except in walls and columns, shall not exceed 5 feet. Free fall in walls and columns shall not exceed 15 feet.
5. Continuous intermediate screed strips set prior to concrete placement are required for slabs cast over steel deck, place screeds along beam lines. Set screeds and adjust as necessary to achieve proper slab elevation and thickness, allowing for beam camber and deflection.
6. Placing Concrete Slabs: Deposit and consolidate concrete slabs in a continuous operation, within limits of construction joints, until the placing of a panel or section is completed.
7. Environmental Requirements:
    a. Cold Weather Placement: When depositing concrete after the first frost or when the mean daily temperatures are below 40 degrees F., follow recommendations of ACI 306.1. Provide sufficient protection material in advance of the time when daily mean temperatures are expected to drop below 40 degrees F. Provide strong and secure weather protection around the building for at least one story above and one story below the floor being concreted to allow the floor to maintain temperatures between 50 and 70 degrees F. for not less than 72 hours after depositing. Obtain one (1) temperature reading of air at floor level for each 600 square feet of floor area just prior to concreting, and provide additional heat should the measured temperature be less than 50 degrees F. Record and submit temperature readings for Architect/Engineer review no later than 24 hours after concreting.
        1) The specified non-chloride accelerator or high-early strength Type III cement may be used when approved by the Architect/Engineer. Do not place concrete without approval of the Architect/Engineer on days when temperature at 9:00 a.m. is below 30 degrees F. Job-cured cylinders for verification of strength and/or the adequacy of the Contractor's protective methods may be required by the Architect/Engineer.
        2) "Freeze Resistant" Concrete: ASTM C1622, "Standard Specification for Cold Weather Admixture Systems and Chapter 9 of ACI 212.3R-10". The contractor shall prepare a plan for placing, finishing and curing procedures that assure the specified hardened properties are achieved.
    b. Hot Weather Placement: When depositing concrete in hot weather, follow recommendations of ACI 305.1. The temperature of concrete at time of placement shall

not exceed 90 degrees F. Protect to prevent rapid drying. Start finishing and curing as soon as possible. When the air temperature is expected to exceed 90 degrees F., the Contractor shall obtain approval from the Architect/Engineer of the procedures to be used in protecting, depositing, finishing, and curing the concrete. The specified water reducing retarding admixture may be used upon approval of the Architect/Engineer. The use of continuous wetting or fog sprays may be required by the Architect/Engineer for 24 hours after depositing or the work may be restricted to evenings or nights, especially in times of low humidity.

E. Consolidating:

1. Maintain one standby vibrator for every three vibrators used.
2. Consolidate placed concrete by internal vibrating equipment with a minimum frequency of 7000 rpm, supplemented by hand-spading, rodding or tamping. Use equipment and procedures for consolidation of concrete in accordance with ACI 309.
3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than visible effectiveness of machine. Place vibrators to rapidly penetrate placed layer and at least 6" into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation of mix.
4. Consolidate concrete during placing operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.

3.05 FINISHES

A. Unspecified form finishes. If the finish is not designated in the contract documents the following finishes shall be used as applicable.

1. Rough Form Finish: For all concrete surfaces NOT exposed to public view.
2. Smooth Form Finish: For all concrete surfaces exposed to public view.

B. Finish of Formed Surfaces:

1. Rough Form Finish: Provide rough form finish for formed concrete surfaces not exposed to view in the finish work and in parking garages unless otherwise indicated. This is the concrete surface having texture imparted by form facing material used, with tie holes and defective areas repaired and patched and fins and other projections exceeding 1/4" in height rubbed down or chipped off.
2. Smooth Form Finish: Provide smooth form finish for formed concrete surfaces exposed to view (except parking garage, unless noted otherwise), or that are to be covered with a coating material applied directly to concrete, or a covering material applied directly to concrete, such as waterproofing, dampproofing, painting or other similar system. This is as-cast concrete surface obtained with selected form facing material, arranged orderly and symmetrically with a minimum of seams. Repair and patch defective areas with fins or other projections completely removed and smoothed.
3. Smooth Rubbed Finish: Provide smooth rubbed finish to scheduled concrete surfaces, which have received smooth form finish treatment, not later than one day after form removal. Moisten concrete surfaces and rub with carborundum brick or other abrasive until a uniform color and texture is produced. Do not apply cement grout other than that created by the rubbing process.
4. Grout Cleaned Finish: Provide grout cleaned finish to scheduled concrete surfaces which have received smooth form finish treatment.
    a. Combine one part Portland Cement to 1-1/2 parts fine sand by volume, and mix with water to consistency of thick paint. Proprietary additives may be used at Contractor's option. Blend standard Portland Cement and white Portland Cement, amounts

determined by trial patches, so that final color of dry grout will closely match adjacent surfaces.

b. Thoroughly wet concrete surfaces and apply grout to coat surfaces and fill small holes. Remove excess grout by scraping and rubbing with clean burlap. Keep damp by fog spray for at least 36 hours after rubbing.

5. Related Unformed Surfaces: At tops of walls, horizontal offsets, surfaces occurring adjacent to formed surfaces, strike-off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.
6. Exposed Ceilings: Where the underside of horizontal concrete surfaces remain as the ceiling of occupied or usable space at stairways, exercise exceptional care in the selection, installation, alignment, and removal of formwork to produce a clean, smooth surface. Tape all form joints. Remove all form oil at area to be covered before applying tape.

C. Unspecified Slab Finishes: When type of finish is not specified in the contract documents, the following finishes shall be used as applicable.

1. Scratched Finish: For surfaces intended to receive bonded application cementitious toppings or other applications.
2. Floated Finish: For surfaces intended to receive roofing, waterproofing membranes, or sand bed terrazzo.
3. Troweled Finish: For floors intended as walking surfaces or for reception of floor coverings.
4. Broom or Belt Finish: For sidewalks and garage floors and ramps.
5. Non-Slip: For exterior platforms, steps, and landings; and for exterior and interior pedestrian ramps.

D. Monolithic Slab Finishes:

1. Scratch Finish: Apply scratch finish to monolithic slab surfaces that are to receive concrete floor topping or mortar setting beds for tile, Portland Cement terrazzo, and other bonded applied cementitious finish flooring material, and as otherwise indicated. Finish surfaces to tolerance specified below. Slope surfaces uniformly to drains where required. After leveling, roughen surface before final set with stiff brushes, brooms, or rakes.
2. Float Finish: Apply float finish to monolithic slab surfaces to receive trowel finish and other finishes as hereinafter specified, and slab surfaces which are to be covered with membrane or elastic waterproofing, membrane or elastic roofing, or sand-bed terrazzo, and as otherwise indicated. Do not work surface until ready for floating. Begin floating when surface water has disappeared or when concrete has stiffened sufficiently to permit operation of power-driven floats, or both. Consolidate surface with power-driven floats, or by hand-floating if area is small or inaccessible to power units. Check and level surface plane to a tolerance as specified below. Cut down high spots and fill low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat surface to a uniform, smooth, granular texture.
3. Trowel Finish: Apply trowel finish to monolithic slab surfaces to be exposed to view, and slab surfaces to be covered with resilient flooring, carpet, ceramic or quarry tile, paint, or other thin-film finish coating system. After floating, begin first trowel finish operation using power-driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and with a level surface to a tolerance as specified below. Grind smooth surface defects which would telegraph through applied floor covering system.
4. Trowel and Fine Broom Finish: Where ceramic or quarry tile is to be installed with thin-set mortar, apply trowel finish as specified above, then immediately follow with slightly scarifying surface by fine brooming.
5. Nonslip Broom Finish: Apply nonslip broom finish to garage floors and ramps with less than 6% slope, exterior concrete platforms, steps and ramps, and elsewhere as indicated. Immediately after trowel finishing, slightly roughen concrete surface by brooming with fiber

bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.

6. Rake Finish: Provide a rake finish to all ramps exceeding a 6% slope. Finish shall be applied perpendicular to direction of traffic.
7. Chemical-Hardener Finish: Apply chemical-hardener finish to interior concrete floors where indicated. Evenly apply each coat, and allow 24 hours for drying between coats Apply proprietary chemical hardeners in accordance with manufacturer's printed instructions. After final coat of chemical-hardener solution is applied and dried, remove surplus hardener.
8. Nonslip Aggregate Finish: Apply nonslip aggregate finish to concrete stair treads, platforms, ramps, and elsewhere as indicated on the Architect's Drawings After completion of float finishing, and before starting trowel finish, uniformly spread 25 lbs. of dampened nonslip aggregate per 100 sq. ft. of surface. Tamp aggregate flush with surface using a steel trowel, but do not force below surface. After broadcasting and tamping, apply trowel finishing as herein specified. After curing, lightly work surface with a steel wire brush or an abrasive stone and water to expose nonslip aggregate.
9. Traffic Surfaces in Parking Facility:
    a. Begin floating after bleeding of water through surface of concrete has been completed and water sheen has disappeared from concrete surface. Finish slab surfaces using a wood or magnesium float to achieve a rough swirl texture.
    b. Finish to tolerance per paragraph "Finishes" of these specifications.
    c. Finish concrete slabs to proper elevations to ensure surface moisture will drain freely to floor drains.

3.06 CONCRETE FINISH MEASUREMENT AND TOLERANCES

A. Extra concrete: The contractor shall include in his bid any additional concrete required to achieve the specified slab surface finish tolerance.

B. Concrete floor finish tolerances:

1. Class AA: F_F 50 / F_L 35
2. Class AX: F_F 40 / F_L 25
3. Class BX**:** F_F 25 / F_L 20
4. Class CX: F_F 20 / F_L 13

C. Slab finishes and specified tolerance classes.

1. Scratch finish: Class CX tolerance.
2. Floated finish: Class BX tolerance.
3. Troweled finish: Class AX tolerance.
4. Exposed aggregate finish: Class BX tolerance.

D. Slab Elevations:

1. Slabs on grade: Within 1/2 inch of the elevation shown on drawings.
2. Supported slabs: Within 1/2 inch of the elevation shown on drawings.

3.07 CONCRETE CURING AND PROTECTION

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Maintain concrete with minimal moisture loss at a relatively constant temperature for the period necessary for hydration of the cement and hardening of concrete. Curing shall commence as soon as free water has disappeared from the concrete surface after placing and finishing. The curing period shall be 7 days for all concrete except high-early strength concrete which shall be cured for 3 days minimum. Curing shall be in accordance with ACI 308.1 procedures. Avoid rapid drying at the end of the curing period.

B. Curing Methods: Perform curing of concrete by moisture curing, by moisture-retaining cover curing, by curing compound, or by combinations thereof, as herein specified. The Contractor shall choose a curing method that is compatible with the requirements for subsequent material application on the concrete surface.

1. Provide moisture curing by one of the following methods:
   a. Keep concrete surface continuously wet by covering with water.
   b. Continuous water-fog spray.
   c. Covering concrete surface with specified absorptive cover, thoroughly saturating cover with water and keeping it continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with 4" lap over adjacent absorptive covers.
      1) Place absorptive cover to provide coverage of concrete surfaces and edges, with 4" lap over adjacent absorptive covers.
2. Provide moisture-cover curing as follows:
   a. Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3" and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
3. Provide curing compound to interior slabs with resilient flooring, carpet over cushion, or left exposed; and to exterior slabs, walks and curbs as follows:
   a. Apply specified curing compound to concrete slabs as soon as final finishing operations are complete (within 30 minutes). Apply to underside of slabs following removal of forms.
   b. Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's directions.
   c. Recoat areas subjected to heavy rainfall within 3 hours after initial application.
   d. Maintain continuity of coating and repair damage during curing period.
   e. Before using membrane curing compound on surfaces that are to be covered with coating material applied directly to concrete, liquid floor hardener, waterproofing, dampproofing, membrane roofing, flooring (such as ceramic or quarry tile, glue-down carpet), painting, and other coatings and finish materials, demonstrate that the membrane can be satisfactorily removed before the subsequent application is made, or the membrane can serve satisfactorily as the base for the later application.

C. Curing Formed Surfaces: Where wooden forms are used, cure formed concrete surfaces, including undersides of beams, underside of supported slabs and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed.

1. When forms are removed, continue curing by methods specified above, as applicable.

D. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, floor topping, and other flat surfaces by application of appropriate curing method.

1. Final cure concrete surfaces to receive liquid floor hardener or finish flooring by use of moisture-retaining cover, unless otherwise directed.

E. During hot and cold weather, cure concrete in accordance with ACI 305.1 and ACI 306.1.

3.08 REPAIR OF FORMED SURFACE DEFECTS

A. Allow Architect/Engineer to observe concrete surfaces immediately upon removal of forms.

B. Modify or replace concrete not conforming to required lines, details, and elevations.

C. Repair or replace concrete not properly placed resulting in excessive honeycombing and other defects. Patch, repair, or replace exposed finished concrete as directed by the Architect/Engineer.

D. Patching of tie holes is [not] required.

E. Repair defects in structural concrete elements as follows:

1. Deep Defects Exposing Reinforcing: Chip to sound concrete and clean thoroughly to remove all loose concrete and dust. Apply thin coat of specified epoxy adhesive. Form and pour, or dry pack with specified nonmetallic, non-shrink grout, prior to development of tack-free condition of epoxy bonder. Strip forms after grout has hardened and provide specified finish. Moist cure or apply specified clear curing and sealing compound immediately after finishing.
2. Defects Greater Than 1/2 In. Depth not Exposing Reinforcing: Chip, clean and apply specified epoxy adhesive. Dry pack using specified nonmetallic, non-shrink grout prior to development of tack-free condition of epoxy bonder. Provide specified finish and cure.
3. Defects Less Than 1/2 in. Depth and Tie Holes:
   a. For concrete having a specified compressive strength of 5000 psi or less: Chip and clean per paragraph in this section. Dry pack per paragraph in this section. Finish and cure as required.
   b. For concrete having a specified compressive strength greater than 5000 psi: Chip and clean per paragraph in this section. At Contractor's option, dampen surface and apply the specified repair mortar followed by specified finish (no curing required); or apply thin coat of the specified bonding compound followed by dry pack per paragraph in this section. Finish and cure as required.
4. Other equivalent repair procedures may be used subject to review and acceptance by the Architect/Engineer.

3.09 REPAIR OF UNFORMED SURFACE DEFECTS

A. Defects which adversely affect the durability of the concrete or finish. Unacceptable surface defects shall include, but not necessarily be limited to, crazing, cracks in excess of 0.01" wide, or which penetrate to the reinforcement or completely through non-reinforced concrete, regardless of width, spalling, pop-outs, honeycomb, rock pockets and other objectionable conditions.

B. Cracks larger than 0.01" wide shall be filled with epoxy injection or other patching system acceptable to the Architect / Structural Engineer.

C. Correct high areas in unformed surfaces by grinding after concrete has cured at least 14 days.

D. Correct low areas in unformed surfaces during, or immediately after, completion of surfaces, finishing operations by cutting out low areas and replacing with fresh concrete. Finish repaired areas to blend into adjacent concrete surfaces.

E. Use the specified underlayment compound or repair mortar.

3.10 REMOVAL OF FORMS AND SHORES, RESHORING

A. Removal of Forms: (Supplement and Modify ACI 301 as follows):

1. Formwork not supporting weight of concrete such as sides of beams, walls, columns and similar parts of the work, may be removed after cumulatively curing at not less than 50 degrees F. for 24 hours after placing the concrete provided the concrete is sufficiently cured to be undamaged by form removal operations and provided that supplementary curing and protection is provided for the exposed concrete.
2. Formwork supporting weight of concrete such as beam soffits, joists, slabs and other structural elements shall not be removed in less than 14 days or until concrete has attained 75% of design strength at 28 days, whichever is greatest.
   a. Form removal time may be altered if a reshoring program is used that is acceptable to the Architect/Engineer.
   b. In place compressive strength of cast-in-place concrete shall be determined by testing field-cured concrete specimens representative of that concrete.

1) Field-cured concrete specimens (as required by the Contractor for early form removal) shall be made and tested by the Owner's testing facility and paid for by the Contractor.

3. Form facing material may be removed 4 days after placement only if shores and other vertical supports have been designed and arranged to permit removal of form facing material without loosening or disturbing shores and supports.

B. Reshoring: (Supplement and Modify ACI 301 as follows):

1. Remove forms and re-shore in a planned sequence to avoid damage to partially cured concrete. Locate and provide adequate reshoring to safely support the work without excessive stress or deflection at time of form removal.
   a. Reshoring is defined as follows: Strip several entire bays. Allow slab to deflect. Reinstall shores. Structure carries its own self weight. No initial load in reinstalled shores.
2. A minimum of two (2) levels of reinstalled shores in addition to the level of formwork is required to support one level of newly poured concrete.
3. Keep reinstalled shores in place a minimum of 15 days after placing upper tier, and longer if required until the concrete has attained its required 28-day strength and until heavy loads due to construction operations have been removed.

3.11 NON-SHRINK GROUT

A. Grout column base plates, equipment bases and other locations noted on the Drawings with non-shrink grout.

B. Perform all grouting in accordance with recommendations of ACI and the grout manufacturer's printed specifications for site preparation, product mixing and placing.

C. Drypack: Zero slump, cement-sand mix, proportion determined by trial to produce 7000 psi compressive strength at 28 days.

3.12 TOLERANCES

A. TOLERANCES FOR FORMED SURFACES

1. Variation from plumb:
   a. In the lines and surfaces of columns, piers, walls and in arrises:
      1) In any 10 ft. of length 1/4 in.
      2) Maximum for the entire length 1 in.
   b. For exposed corner columns, control-joint grooves, and other conspicuous lines:
      1) In any 20 ft. length 1/4 in.
      2) Maximum for the entire length 1/2 in.
2. Variation from the level or from the grades specified in the contract documents:
   a. In slab soffits, ceilings, beam soffits, and in arrises, measured before removal of supporting shores:
      1) In any 10 ft. of length 1/4 in.
      2) In any bay or in any 20 ft. length 3/8 in.
      3) Maximum for the entire length 3/4 in.
   b. In exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines:
      1) In any bay or in 20 ft. length 1/4 in.
      2) Maximum for the entire length 1/2 in.
3. Variation of the linear building lines from established position in plan and related position of columns, walls, and partitions:
   a. In any bay 1/2 in.
   b. In any 20 ft. of length 1/2 in.

c. Maximum for the entire length 1 in.

4. Variation in the sizes and location of sleeves, floor openings, and wall openings +1/4 in.
5. Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls: minus 1/4 in., plus 1/2 in.
6. Footings
   a. Variations in dimensions in plan: Minus 1/2 in, plus 2 in.
   b. Misplacement or eccentricity: 2 percent of the footing width in the direction of misplacement but not more than 2 in.
   c. Thickness:
      1) Decrease in specified thickness: 5 percent
      2) Increase in specified thickness: No limit
7. Variation in steps:
   a. In a flight of stairs: Rise +1/8 in., Tread +1/4 in.
   b. In consecutive steps: Rise +1/16 in., Tread +1/8 in.
      1) Tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel, dowels, or embedded items.

3.13 MISCELLANEOUS CONCRETE REQUIREMENTS

A. All other concrete work indicated on the drawings shall be provided and installed in conformance to these specifications:

1. Equipment Bases: Install concrete bases for all pumps, boilers, tanks, fans, transformers, floor mounted electrical equipment, etc., including anchor bolts and inserts in accordance with setting diagrams furnished by the Contractor responsible for installing the equipment. Finish all bases in a workmanlike manner with a troweled finish. The bases shall be located and sizes determined by the Contractor furnishing the equipment.
2. Concrete Benches and Planters: Form and pour in place all exterior concrete benches and planters as indicated. Reinforce as detailed. Finish bench tops with smooth troweled finish and slope slightly for drainage.
3. Under Floor Duct Encasement: Pour concrete around under floor mechanical ducts as indicated on the mechanical drawings. Coordinate with ductwork installer.
4. Flagpole Base: Form, reinforce, and pour flag pole bases as indicated on electrical drawings. Coordinate installation of conduit and anchor bolts with electrical contractor.
5. Light Pole Bases: Form, reinforce, and pour light pole bases as indicated on electrical drawings. Coordinate installation of conduit and anchor bolts with electrical contractor.
6. Filling-In: Fill-in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place, and cure concrete as herein specified, to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete work.
7. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

END OF SECTION

SECTION 033520 - CONCRETE FINISHING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Decorative concrete polishing
   2. Concrete stain
   3. Concrete sealer

B. Refer to Division 03 Section “Cast-In Place Concrete” for balance of information on concrete formed finishes

1.2 SUBMITTALS

A. Product Data: For type of manufactured material and product indicated.

B. Material Certificates: Signed by manufacturers certifying compliance of floor and slab treatments.

C. Maintenance Data: Provide manufacturer’s instructions for maintenance of installed work, including methods and frequency recommended for maintaining optimum condition under intended use. These instructions should contain precautions against cleaning products and methods, which may be detrimental to finishes and performance.

1.3 QUALITY ASSURANCE

A. Coordination; Verify compliance between all components of system prior to the application.

B. Applicator Qualifications: Engage an experienced applicator who employs only persons trained and approved by concrete sealer manufacturer for application of manufacturer's products.

C. Source Limitations: Obtain each specified material from same source and maintain high degree of consistency in workmanship throughout Project

D. Slip Resistance: Static coefficient of friction shall be 0.6 for level floors and 0.8 for ramped surfaces as recommended by the ADA Accessibility Guidelines (ADAAG).
   1. Testing shall be in accordance with ASTM C 1028 or use of similar devices recognized by ADAAG.

E. Static Coefficient of Friction: A reading of not less than 0.5 for level floor surfaces shall be achieved and documented, as determined by certified an NFSI walkway auditor using the NFSI 101-A quality control test.

F. Field Sample Panels for Concrete Polish: After approval of samples, produce field sample panels to demonstrate the approved range of selections made under Sample submittals. Produce a minimum of three sets of full-scale panels, approximately 48 by 48 inches minimum, to demonstrate the expected range of finish, color, and appearance variations.
   1. Locate panels as indicated or, if not indicated, as directed by Architect.
   2. Maintain field sample panels during construction in an undisturbed condition as a standard for judging the completed Work.
   3. Demolish and remove field sample panels when directed.

G. Concrete Sheen Tested according to ASTM D 523-08; Readings shall be taken not less than 10 ft (3 m) on center in field areas and within12 inches (0.3 m) of floor area perimeters. In no case shall a reading be below 2 percent of specified minimum sheen:

1. Level A Sheen – Low Reflectivity readings of less than 35.
2. Level B Sheen – Medium Reflectivity readings of 36 to 50.
3. Level C Sheen – Medium High Reflectivity readings of 51 to 65.
4. Level D Sheen – High Reflectivity readings of 66 or higher.

H. Environmental limitations: Comply with manufacturer's written instructions for substrate temperature and moisture content, ambient temperature and humidity, ventilation, and other conditions affecting topping performance
1. Concrete must have a Floor Flatness rating of at least 40.
2. Concrete must have a Floor Levelness rating of at least 40.
3. Concrete shall have the minimum 45-day compressive strengths as follows:
a. Concrete Not Exposed to Freeze Thaw Conditions: 3000 psi.

1.4 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty: Submit a written warranty, executed by the applicator and concrete sealer manufacturer, covering materials and labor, agreeing to repair or replace materials that fail to provide water repellency within the specified warranty period. Warranty does not include deterioration or failure of coating due to unusual weather phenomena, failure of prepared and treated substrate, formation of new joints and cracks in excess of 1/16 inch wide, fire, vandalism, or abuse by maintenance equipment.

PART 2 - PRODUCTS

2.1 CONCRETE SEALER and DENSIFIER

A. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic materials and proprietary components; odorless; colorless; that penetrates, hardens, and densifies concrete surfaces.
1. Basis of Design: Bomanite Stain Guard, Lithium Silicate

2.2 STAIN

A. Concrete stain, hydrolyzed lithium quartz penetrating compound, compatible with polishing system:
1. As selected from manufacturers full range

2.3 POLISHING CONCRETE SYSTEM

A. Basis of Design Products: The polishing concrete system is based on Bomanite System Vitraflor by Colorado Hardscapes.
1. Finish: Light sand exposure.

B. Accessories:
1. Dust Extraction System (Vacuum)
2. Grinding Heads.
3. Grinding Pads and Abrasives
4. Curing products as recommended by manufacturer.
5. Protective cover.
6. Grout
7. Joint sealant

C. Edges: Polished, within 1/2 inch of vertical surface

D. Provide polishing equipment as required for achieve gloss desired, including but not limited to;
   1. Micro polisher
   2. Large platform polisher
   3. Low speed grinder
   4. Diamond abrasives and blades;
      a. Metal bonded diamonds 18/20, 30/40 Grit of soft medium and hard bonded metal.
      b. Transitional Diamonds, Ceramic Bonded #0, #1, #2 Grit
      c. Resin Bonded Diamonds – 200, 400, 800, Grit

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean substrate of substances that might interfere with penetration or performance of concrete sealer. Test for moisture content, according to sealer manufacturer's written instructions, to ensure surface is sufficiently dry.
   1. Formed Concrete: Remove oil, curing compounds, laitance, and other substances that could prevent adhesion or penetration of concrete sealers.

B. Repair cracks and joints in accordance with manufacturers recommendations

C. Protect adjoining work, including sealant bond surfaces, from spillage or blow-over of concrete sealer. Cover adjoining and nearby surfaces of aluminum and glass if there is the possibility of concrete sealer being deposited on surfaces. Cover live plants and grass.

D. Coordination with Sealants: Do not apply concrete sealer until sealants for joints adjacent to surfaces receiving water-repellent treatment have been installed and cured.
   1. Water-repellent work may precede sealant application only if sealant adhesion and compatibility have been tested and verified using substrate, concrete sealer, and sealant materials identical to those used in the work.

E. Moisture Vapor and Alkalinity Testing
   1. Test existing concrete floors for alkalinity/pH, according to method indicated in ASTM F710. Acceptable results: pH between 9 and 10.
   2. Test existing concrete for moisture vapor transmission according to methods indicated in ASTM F1869. Acceptable results: not more than 5 pounds per 1,000 square feet in 24 hours.
   3. Test existing concrete for relative humidity using in situ probes according to ASTM F2170. Acceptable results: not more than 80 percent.
   4. Verify tolerances with flooring manufacturer.

3.2 APPLICATION OF SEALER

A. Newly placed concrete should not receive sealer prior to 7 days cure time. Apply a moderate-saturation spray coating of concrete sealer on surfaces indicated for treatment using low-pressure spray equipment. Immediately work sealer into surface until product begins to form a gel. Squeegee or vacuum off excess material, leaving no puddles of sealer.

B. Confirm location of sealer with Architect.

3.3 STAIN

A. Apply stain in accordance with manufacturers requirements.

3.4 POLISHING

A. Polish to 800 Grit

B. Apply polished concrete finish system to cured and prepared slabs.
   1. Machine grind floor surfaces to receive polished finishes level and smooth.
   2. Apply penetrating liquid floor treatment for polished concrete in polishing sequence and according to manufacturer's written instructions, allowing recommended drying time between successive coats.
   3. Continue polishing with progressively finer-grit diamond polishing pads to gloss level, to match approved mockup.
   4. Control and dispose of waste products produced by grinding and polishing operations.
   5. Neutralize and clean polished floor surfaces.

3.5 CLEANING

A. Protective Coverings: Remove protective coverings from adjacent surfaces and other protected areas.

B. Immediately clean concrete sealer from adjoining surfaces and surfaces soiled or damaged by water-repellent application as work progresses. Repair damage caused by water-repellent application. Comply with manufacturer's written cleaning instructions.

3.6 ONGOING MAINTENANCE OF POLISHED CONCRETE FLOORING

A. Maintaining the Polished Concrete System and adherence to a recommended cleaning schedule will help the floor hold its mechanically polished gloss longer and greatly reduces the absorption of spilled liquids. The treated concrete floor is easily maintained by regular cleaning with the Maintenance/Post Cleaning procedure, accompanied by Micro-Polishing.

B. Newly Installed Polished Concrete System
   1. Restrict water cleaning for 72 hours after installation. Use only a dry mop to clean. Avoid putting mats or covering treated surface to allow coating to fully cure out.
   2. DO NOT USE cleaners that are acidic or that have citrus (de-limonene) or Butyl compounds. Although the Polished Concrete System is chemical and stain resistant, the application of these high acid cleaners may etch the surface and cause a residual stain. Regular maintenance and cleaning will help prolong surface shine.

END OF SECTION 033520

SECTION 03 3800
POST-TENSIONED CONCRETE

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of contract, including general and supplementary conditions and Division 1 specification sections, apply to work of this section.

1.02 DESCRIPTION OF WORK

A. Work under this Section consists of furnishing all labor, material and equipment necessary for, and incidental to, the execution and completion of post-tensioning work as shown on the drawings and specified herein.
   1. Furnish all labor, materials, tools, plant, equipment and transportation services necessary for furnishing, installing and stressing of all post-tensioning tendons.
   2. Furnish and install all mild reinforcing steel shown on the drawings including reinforcing required for support of tendons and reinforcing steel required at end anchorages.
   3. Include grouting of tendon enclosures, furnishing and installation of anchorages, distribution plates, removal of excess tendon after anchorage if appropriate, and sealing and protecting tendon and anchorage upon completion of work.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Concrete Work, - Division 3.

B. Sleeves, inserts, anchors, specified for plumbing and piping, ductwork, electrical and mechanical items furnished and installed under other specification sections, Divisions 15 & 16.

C. Structural Precast Concrete, Division 3.

D. Architectural Precast Concrete, Division 3.

1.04 CODES AND STANDARDS

A. Work under this section shall be subject to all applicable provisions of the state and local building and safety codes and other codes and standards referenced in this section. All references refer to latest edition unless noted otherwise.
   1. American Concrete Institute "Building Code Requirements for Reinforced Concrete", ACI 318, Chapter 18.
   2. American Concrete Institute "Specifications for Structural Concrete for Buildings", ACI 301, Section 9.
   3. Comply with requirements of the "Manual of Standard Practice", published by the Concrete Reinforcing Steel Institute (CRSI).

1.05 QUALITY CONTROL

A. The Contractor is responsible for and shall control the quality of all materials and workmanship, including the workmanship and materials furnished by his subcontractors and suppliers.

B. Inspections and tests performed by the Owner as part of a quality assurance program will not relieve the Contractor of his responsibility to provide materials and workmanship in compliance with specified requirements.

C. The Post-tensioning Contractor shall cooperate with all testing and inspection personnel employed to perform field quality assurance tests and inspections. See Division 1, "Inspections & Testing Services" section of the specifications for required tests and inspections to be performed by the Owner's Testing Laboratory.

D. The Contractor shall be responsible for correction of work which does not conform to specified requirements. Correct nonconforming work in a manner, and with materials, approved by the Architect/Engineer. The cost of extra work incurred by the Architect/Engineer to approve corrective work shall be borne by the Contractor.

1.06 QUALITY ASSURANCE

A. The Owner will engage a qualified Testing Agency, approved by the Engineer of Record, to perform the testing required by ACI-318 Building Code Requirements, Chapter 3, and these specifications. The Testing Agency shall comply with the requirements of ASTM E329 and shall furnish written certification indicating such compliance. The testing program shall include, but not be limited to, the following testing and inspections.
   1. Verify calibration of hydraulic jacks used on project. Provide continuous inspection during placement of tendons and stressing operations.
   2. Record elongation and anchor forces at each tendon.
   3. Submit reports to Architect/Engineer upon completion of each day's placement and stressing operation.
   4. Provide continuous inspection during placement of tendons and stressing operations.

B. See Division 1, "Code Required Special Inspections and Procedures".

1.07 CONTRACTOR QUALIFICATIONS

A. Post-tensioning work shall be performed by a Contractor with a minimum of five years of successful experience in post-tensioning work similar in design and scope to this project.
   1. Bidding contractors shall submit evidence of such experience for Architect/Engineer's approval.

1.08 SAFETY

A. In addition to normal safety precautions required by law and commonly accepted as good construction practices; provide all safety measures peculiar to this type of work and as recommended by material suppliers and equipment manufacturers.
   1. Do not permit workers to stand behind stressing jacks during stressing operations.

1.09 DELIVERY, STORAGE AND HANDLING

A. Arrange deliveries to prevent lengthy storage at project site and to provide sufficient quantities to permit continuity of work.

B. Protect post-tensioning steel and end anchorages against damage and rust or other results of corrosion at all times from manufacture to final stressing.

C. Material that has sustained physical damage at any time, including but not limited to corrosion, injurious

marks, scratches, seams, or sharp kinks, will be rejected.

D. Material shall be stored off the ground on horizontal pallets.

1.10 DESIGN CRITERIA

A. Design shall conform to the criteria stated herein.

B. Conform to all requirements of "Building Code Requirements for Reinforced Concrete (ACI 318).
   1. See plans for minimum concrete strength (f'c) and minimum concrete strength at time of prestressing.

1.11 SUBMITTALS

A. Shop Drawings: Submit shop drawings indicating, in addition to the post-tensioning system, the following information:
   1. Tendon layout and dimensions locating tendons in plan at all points. Detail horizontal curvature of tendons at blockouts and anchorages. Show all openings in slabs and beams, including stressing pockets if any.
   2. Tendon profiles showing chair heights and location for each tendon and the method of tendon support. Include all support bars required to support tendons.
   3. Calculated elongation of each tendon at jacking point.
   4. Details of special bursting reinforcement in tendon anchorage zones required for the contemplated anchorage devices and arrangement.
   5. Details, location and arrangement of tendon dead end and stressing end anchorage devices showing all mild steel reinforcing in the immediate vicinity to avoid placing conflicts.
   6. Location and details of all construction joints showing sequence of construction and isolation strips, etc.
   7. Tendon and mild steel placing sequence at all locations. Indicate coordinated placing sequence of post-tensioning and conventional reinforcing.
   8. Shop drawings, tests, calculations, etc., shall be prepared and performed under the supervision of a Professional Engineer, registered in the state where the project is located. Shop drawings shall bear the professional seal of the responsible Engineer.

B. Post-Tensioning Procedure: Furnish complete post-tensioning procedure to include the following:
   1. Jacking sequence and methods.
   2. Jacking force and jack pressure.
   3. Maximum temporary jacking force and jack pressure.
   4. Jack clearance requirements.
   5. One sample form of the field record of stressing operations.
   6. Method of determining tendon slack, if any.

C. Calculations: Submit calculations as follows for review and acceptance by the Architect/Engineer along with the shop drawings for each portion of the work.
   1. Average final effective force in each tendon after all losses. The calculated final effective force at any point along a tendon profile shall not be less than 90 percent, or greater than 115 percent, of the average final effective force in the tendon. Additional short tendons may be added at the Contractor's option and expense to overcome the effect of losses at points distant from stressing points. Anchorage and long-term losses shall be based on substantiating data acceptable to the Architect/Engineer. In the absence of such data, calculate anchorage and long term losses based on the following:
      a. Seating loss=1/4 in.
      b. Shrinkage strain in concrete=0.0004 in./in.
      c. Creep strain in concrete=2.5 times elastic strain in concrete upon anchorage

d. Relaxation in tendons=0.05 times strain in tendon upon anchorage

2. Friction losses along the tendon shall be calculated in accordance with ACI 318, paragraph 18.6.2, including the effects of both horizontal and vertical curvature and based on friction and wobble coefficients determined from field tests on other projects of similar size, proportions, material properties, and construction techniques, made within the last year and acceptable to the Architect/Engineer. Field verification of friction and wobble coefficients prior to stressing operations on the first portion of the work constructed is required.
3. Size and number of tendons required to achieve the final design forces indicated on the drawings based on the average final effective force per tendon computed above.
    a. Structural drawings show numbers of tendons required based on an assumed effective prestress force in each tendon as indicated on the drawing. Total number of tendons shall be adjusted upward as required based on final loss calculations. Total number of tendons may be adjusted downward based on final loss calculations.

D. Test Results and Certifications: Submit the following for review and acceptance by the Architect/Engineer not less than four weeks prior to commencement of work:
    1. Mill Tests: Results of certified mill tests (including typical stress-strain curve) from each heat and coil set from which post-tensioning material will be taken. Such results shall include guaranteed ultimate strength, yield strength, elongation, cross-sectional c and modulus of elasticity of the material tested.
    2. Equipment Calibration Tests: Results of certified calibration tests made within the last three months by an independent testing agency of all stressing equipment to be used on the project. Stressing equipment shall be calibrated as a unit consisting of jack, gage, and pump. Components of calibrated units may not be interchanged during the course of the work without recalibration. Contractor shall submit method of identification of all stressing units. Calibration reports shall include a curve relating jack forces to gage readings.
    3. Static and Dynamic Tests: Results of certified test made on each type of the anchoring devices of unbonded tendons proposed to be used in the project.
        a. Static Tests: The test assembly shall consist of standard production quality components and the tendon shall be at least 10 feet long. The test assembly shall be tested in a manner to allow accurate determination of the yield strength, ultimate strength and percent elongation of the complete tendon to insure compliance with this specification. The specimen used for the static test need not be one that has been subjected to dynamic loading.
        b. Dynamic Tests: The first dynamic test shall be performed on a representative specimen and the tendon shall withstand, without failure, 500,000 cycles from 60 percent to 66 percent of its minimum specified ultimate strength, and also 50 cycles from 40 percent to 80 percent of its minimum specified ultimate strength. The period of each cycle involves the change from the lower stress level to the upper stress level and back to the lower. The specimen used for the second dynamic test need not be the same used for the first dynamic test. Systems utilizing multiple strands, wires, or bars may be tested utilizing a test tendon of smaller capacity than the full size tendon. Test tendon shall duplicate the behavior of the full size tendon and generally shall not have less than 10 percent of the full size tendon.
        c. Post-tensioning supplier shall arrange and pay for required static and dynamic tests. Previous tests certifying that the anchorage tested is of the same quality, size and material may be acceptable as determined by the Architect/Engineer.

E. Stressing Record: The post-tensioning contractor shall keep and promptly provide a stressing record for all tendons to the Architect/Engineer and Owner. This record shall include the tendon mark, location and length, stressing unit identification, gauge reading at anchorage, and the calculated and measured tendon elongation at each stressing end of each tendon.

PART 2 PRODUCTS

2.01 DEFINITIONS

A. Tendon: The complete assembly consisting of anchorage and prestressing steel with sheathing when required. The tendon imparts prestressing forces to the concrete.

B. Unbonded Tendons: Tendons in which the prestressing steel is permanently free to move relative to the concrete to which they are applying their prestressing forces.

C. Anchorage: The means by which the prestressing force is permanently transmitted from the prestressing steel to the concrete.

D. Prestressing Steel: That element of a post-tensioning tendon which is elongated and anchored to provide the necessary permanent prestressing force.

E. Coating: Material used to protect against corrosion and/or lubricate the prestressing steel.

F. Sheathing: Enclosure around the prestressing steel to avoid temporary or permanent bond between the prestressing steel and the surrounding concrete.

G. Coupling: The means by which the prestressing force may be transmitted from one partial-length prestressing tendon to another.

H. Bonded Tendons: Tendons which after stressing are bonded to the concrete through grouting or other approved means, and, therefore, are not free to move relative to the concrete.

I. Pipe Sleeves: Standard steel pipes by which column rebars are not bonded with concrete.

2.02 POST-TENSIONING STEEL

A. Wire: Conform to ASTM A-421 (Type BA) "Specifications for Uncoated Stress-Relieved Wire for Prestressed Concrete" including supplement for low-relaxation wire. Do not use oil tempered wires.

B. Strands: Conform to ASTM A-416, Grade 270, "Specification for Uncoated Seven-Wire Stress-Relieved Strand for Prestressed Concrete", including supplement for low-relaxation strand.

C. Prestressed Bars: Conform to ASTM A-722, "Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete".

2.03 POST-TENSIONING TENDONS

A. Unbonded Tendons:
   1. Tendons shall be 1/2 in. diameter seven-wire strand.
   2. Tendons shall be completely shop coated with a non-volatile, low-friction, mineral oil base grease with a rust-preventing additive. The coating material shall remain ductile, free from cracks, and shall not become fluid within a temperature range of -20 degrees F. to +140 degrees F. The coating material shall be chemically stable and non-reactive to cement and material used for sheathing.

2.04 ANCHORAGES AND COUPLINGS

A. Anchorages for unbonded tendons shall develop 100 percent of the minimum specified ultimate strength of the tendons with minimal permanent deformations that will not decrease the required ultimate strength of the anchorage.

B. Couplings shall be used only at locations shown on the drawings or where specifically approved by the Architect/Engineer. All couplings shall develop the ultimate strength of the tendon without exceeding the anticipated set of either the coupling or tendon and shall not reduce the ductility of the tendon below two percent elongation measured over a gage length of 10 feet. Couplings shall be enclosed in sheaths which will permit the necessary movements during stressing.

C. All anchorages, couplers and miscellaneous hardware shall be approved by the International Conference of Building Officials or other agencies of equal stature.

D. Provide distribution plates of welded steel or cast steel bearing assemblies that will permanently support and distribute the load from the anchoring devices as follows:
   1. Do not exceed the following bearing stresses on the concrete:
      a. Immediately after tendon anchorage: $f_b = 0.8$ f'ci (A2/A1-0.2)1/2 equal to but not greater than 1.25 f'ci
      b. After allowance for prestress losses: $f_b = 0.6$ f'c (A2/A1)1/2 equal to but not greater than f'c Where: f'c=Ultimate 28 day compressive strength f'ci=Compressive strength at time of stressing A1=Bearing area of anchor plate of post tensioning tendons. A2=Maximum area of the portion of the anchorage surface that is geometrically similar to, and concentric with, the area of the anchor plate of the post-tensioning tendons.
      f_b=Permissible concrete bearing stress under the anchor plate of post tensioning tendons with the end anchorage adequately reinforced.
      c. As used in the above equations, fb is the average bearing stress, P/A, in the concrete computed by dividing the force P of the prestressing steel by the net projected area, A1, between the concrete and the bearing plate or other structural element of the anchorage which has the function of transferring the force to the concrete.
      d. Special bursting reinforcement, required for the performance of the anchorage, shall be designed and furnished by the tendon supplier.
   2. Bending stresses in the plates induced by the pull of the prestressing steel shall not exceed 20,000 pounds per square inch for structural steel and 15,000 pounds per square inch for cast steel, except if acceptable test data indicates that higher stresses are satisfactory. For high strength steel, correspondingly higher stresses may be permitted.
   3. Provide materials which meet requirements of ASTM A-36 for structural shapes, or ASTM A-148 for cast steel, or high quality materials as required to meet stress requirements.
   4. Design, fabrication and erection shall meet the latest AISC Standards, Welding AWS Standards, including Qualification Test of Welders.
   5. Furnish high-tensile steel bolts and nuts, when so called for on the Drawings, which conform to ASTM A325.
   6. Distribution plates may be omitted, if the bearing area of any anchoring device is sufficiently large so that the local concentrated bearing stresses do not exceed the stresses permitted above or cause local failure.

2.05 SHEATHING

A. Sheathing for Unbonded Tendons: Tendon sheathing for unbonded tendons shall have sufficient tensile strength and water-resistance to prevent irreparable damage and deterioration during transport, storage at job site, and during installation. Sheathing shall be continuous over tendon length to be unbonded. Sheathing shall prevent the intrusion of cement paste and escape of coating material. Sheathing shall be continuous hollow plastic type tube, made with plastic high density material of either polyethylene or polypropylene. The tube wall thickness shall be 0.5 mm minimum. Spirally wrapped sheathing will not be permitted, except to splice or repair hollow tube sheathing.

2.06 CONCRETE

A. As specified under Division 3 Cast-in-Place Concrete, except that no add mixtures containing chlorides may be used.

2.07 MILD STEEL REINFORCING

A. As specified under Division 3, Cast-in-Place Concrete.

PART 3 EXECUTION

3.01 GENERAL

A. Do not place concrete in post-tensioned members until tendons and mild steel reinforcement have been reviewed and approved by Owner's testing agency. Provide a minimum of 24-hours notice prior to concrete placement. Such review will in no way relieve the Contractor of responsibility for proper quantities and placement in the completed construction.

3.02 FORMWORK

A. Provide formwork for post-tensioned elements as specified under Division 3, Cast-in-Place Concrete. Formwork shall not restrain elastic shortening, camber, or deflection resulting from the application of the prestressing force. Provisions shall be made for the gravity load transfer when the prestressing force is applied. When a structure is prestressed in two directions, formwork shall support the loads redistributed by partially completed stressing operations.

B. Form ends shall be prepared and erected prior to tendon placement to assure accurate tendon placement.
   1. Drill forms to receive tendon stressing hardware and anchorages. Comply with placement end anchorage details shown on the post-tensioning Shop Drawings

3.03 INSTALLATION

A. Tendon Placement:
   1. If the post-tensioning supplier is not also the placer, then he shall provide experienced field personnel to train the placer's workmen until they are familiar with and properly trained in the execution of the Work.
   2. Exercise care to prevent damage to tendons during shipping and placing. Tears in unbonded tendon sheathing need not be repaired if less than 6 inches in length and if grease is prominent on exposed wires. The sheathing shall be continuous to within 1/2 inch of the back of all stressing anchorages and within 12 inches of all embedded dead ends, unless shown otherwise on the Drawings. The tendons shall be placed and secured in position in the forms shown on the Drawings under a small tension of approximately 20 pounds per wire so that the curvature of the tendons will be smooth and uniform.
   3. Supports for tendons shall be such as to provide the tendon profiles indicated on the approved Shop Drawings and to insure their remaining in position prior to and during the placing of concrete. Locate supports for tendons at the high and low point of the tendon profile, at 4'-0" maximum on center and at other locations as shown on the Shop Drawings. As a minimum, provide three (3) tendon supports per tendon or bundle of tendons, each bay. Support chairs and slab bolsters must be attached to the form surface by staples or other devices. Tie all tendons to support chairs and slab bolsters. Accessories shall have plastic tips or stainless steel legs. Tendon drape and location shall have precedence over mild steel placement.
   4. Do not displace tendons more than 1'-3" laterally to provide for openings in slabs. Do not displace more than twice on any single tendon and displace only when angular offset does not exceed 1 in 12. Should a displacement greater than 1'-3" be required, shift bearing plate to miss opening. Tendons shall clear openings, drains and electric outlet boxes by a minimum of 2".

5. Securely fasten bearing plates or anchors to end forms with plates and anchorages perpendicular to the longitudinal axis of the tendon.
6. Remove and replace broken strands and strands showing severe fabrication defects.
7. Anchorages at slab edges or beam ends shall be recessed a minimum of 1-1/2 inches. At construction joints, all anchorages or tendon force distribution plates (bearing plates) shall be embedded in the first of the consecutive pours. Flat back castings, plates, etc., which are placed against previously cast concrete and then stressed will not be allowed. Washer type grommets shall be used at construction joints if grout exclusion is necessary for the embedded item. Normal depth pockets at intermediate construction joints shall not be used unless adequate measures are taken to insure that the pocket is completely filled with concrete during subsequent pours.
8. Tendons can be bundled as follows:
    a. For Slabs: Maximum three (3) tendons, all in a row horizontally.
    b. For Beams: Maximum six (6) tendons, three (3) horizontal by two (2) vertical. Bundles must be held together by wiring them every 4'-0" on center.
9. Tendon and tendon anchorage placing tolerances shall be as follows:
    a. Horizontal alignment:
        1) Slabs: +-1 in. total, maximum of 1 in. deviation in any 15 foot of tendon length.
        2) Beams:
            (a) Width 8 in. or less: +-1/8 in.
            (b) Width over 8 in. but not over 24 in.: +-1/4 in.
            (c) Width over 24 in.: +-1/2 in.
    b. Vertical elevation:
        1) Depth 8 in. or less: +-1/8 in.
        2) Depth over 8 in. but not over 24 in.: +-1/4 in.
        3) Depth over 24 in.: +- 1/2 in.
    c. Tendon anchorages shall be placed within +- 1/2 in. of the plan location measured along the tendon length. Bearing surfaces of anchorages shall be concentric with, and perpendicular to, the tendon profile.

B. Rebar Placement:
1. Place mild steel reinforcement as specified under Division 3, Cast-in-Place Concrete and in accordance with the placing sequence defined on the post-tensioned reinforcing Shop Drawings. Maintain 1-1/2 in. minimum clearance between all mild steel reinforcing and tendon anchorage devices.
2. Welding of cross bars or any welding in the vicinity of the tendons will not be allowed. Post-tensioning tendons shall not be used as an electrical ground for welding operations.

C. Other Embedded Items: All inserts and anchors for suspended mechanical and architectural work shall be cast-in-place wherever feasible. Additional fasteners will be permitted only with the approval of the Architect/Engineer and only when it can be shown that the inserts will not spall concrete and are located so as to avoid hitting tendons or anchorages. The Contractor shall locate the tendons on the surface of the slab if drilling or coring is to be done after concrete is placed.

3.04 CONCRETE PLACEMENT

A. Place concrete as specified under Division 3 Cast-in-Place Concrete. Take special precautions to insure proper consolidation of concrete around tendon anchorages. Concrete shall be placed in such a manner as to insure that alignment of post-tensioning tendons remains unchanged. Tendon positioning shall be monitored during the pour.

3.05 STRESSING

A. Safety: Precautions shall be taken to insure that the stressing operation is conducted in a safe manner.

Insertion of shims or wedges shall be performed in a manner to insure safety of workmen's hands. All personnel shall stay clear of the front and rear of ram during stressing operation.

B. Initial job site instruction and supervision of Contractor's personnel in the stressing operation, and necessary calibrated stressing units shall be provided by the tendon supplier. In order to insure that proper calibration is maintained, exercise care in handling stressing equipment.

C. Do not apply prestressing force until the concrete in the members has reached 75 percent of the specified design strength shown on the Drawings. Strength of concrete in place shall be determined from tests of field-cured cylinders made by the Independent Testing Laboratory as specified under Division 3, Cast-in-Place Concrete. Cost of such testing shall be borne by the Contractor.

D. After the concrete has reached specified strength, the tendons shall be stressed by means of hydraulic jacks equipped with accurate reading, calibrated, hydraulic pressure gauges. Certified calibration data shall accompany each hydraulic jack. Stressing equipment shall provide for attachment of test gauge which can be read simultaneously with jack hydraulic gauge. Certified test gauge calibration data shall accompany each test gauge. Jacking force shall be measured by the gauge of the stressing unit and shall be immediately recorded on the stressing record.

E. The stressing operation shall be conducted in a manner recommended by the manufacturer of the prestressing materials and accepted by the Architect/Engineer.

F. The maximum jacking stress in prestressing steel shall not exceed the smaller of 80 percent of the specified minimum ultimate tensile strength or 94 percent of the specified yield strength of the prestressing steel. The prestressing steel shall be anchored at stresses that will result in the retention of final effective forces after all losses of not less than those shown on the drawings. Anchor force shall not exceed 70 percent of specified ultimate strength of prestressing steel.

G. Stressing anchorages shall remain accessible, and excess tendon length at stressing points shall not be removed until the stressing record for those tendons has been reviewed and accepted by the Architect/Engineer. After the stressing records have been reviewed, cut off the excess strand at least 1/2 inch inside the face of the finished concrete surface, but not less than 3/4 inch from the face of the anchorage. Care shall be taken to avoid heating the wedges.
   1. Install encapsulating hardware.

3.06 REMOVAL OF FORMS

A. Formwork and shoring for post-tensioned elements shall not be removed until stressing operation is complete.

B. Beam side forms may be removed prior to stressing if acceptable to the Architect/Engineer.

C. After stressing and formwork removal, conduct reshoring in strict accordance with sequences indicated on Shop Drawings and as required to prevent overloading during additional construction. Retain shores for as many levels as required to support the loads of the subsequent fresh construction and construction loads. If formwork is supported on slabs, reshore a minimum of two (2) consecutive levels.

3.07 ACCEPTANCE OF WORK

A. Prestressing will be deemed acceptable if the total elongation for all tendons in the same direction of an element is between 95 percent and 110 percent of the total calculated elongation of the tendons, and each individual measured elongation is between 90 percent and 115 percent of its calculated value. For flat plate structures with banded arrangement of tendons, the element to which this criterion shall apply is defined as all of the tendons in one band of the banded direction, or all of the tendons in one bay of the uniform direction. For slab systems prestressed in one direction, an element is defined as all of the tendons in one bay of the system.

B. If measured elongations deviate from calculated elongations by more than the specified limits, additional testing, re-stressing, strengthening, or replacement of the affected elements may be required at the discretion of the Architect/Engineer. The cost of any remedial work required shall be borne by the Contractor.

C. After the completion of work specified by this section, and within one month prior to the scheduled completion of the project, an inspection of all post-tensioned slabs exposed as wearing surfaces will be made by the Architect/Engineer. The Contractor shall repair all cracks and other unacceptable conditions identified by this inspection in a manner acceptable to the Architect/Engineer. The cost of any repairs required shall be borne by the Contractor.

END OF SECTION

SECTION 035413 - GYPSUM CEMENT UNDERLAYMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes gypsum-cement-based, self-leveling underlayment for application below interior floor coverings.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Product certificates.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Installer who is approved by manufacturer for application of underlayment products required for this Project.

B. Product Compatibility: Manufacturers of underlayment and floor-covering systems certify in writing that products are compatible.

PART 2 - PRODUCTS

2.1 GYPSUM-CEMENT-BASED UNDERLAYMENT

A. Underlayment: Gypsum-cement-based, self-leveling product that can be applied in minimum uniform thickness of 1/8 inch and that can be feathered at edges to match adjacent floor elevations.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Basis of Design: Maxxon Corporation; Gyp-Crete.
      b. Allied Custom Gypsum; AccuCrete.
      c. Euclid Chemical Company (The); Flo-Top.
      d. USG Corporation; Levelrock.
   2. Cement Binder: Gypsum or blended gypsum cement as defined by ASTM C 219.
   3. Compressive Strength: In a range between 2000 psi to 3200 psi at 28 days when tested according to ASTM C 109/C 109M.
   4. Underlayment Additive: Resilient-emulsion product of underlayment manufacturer, formulated for use with underlayment when applied to substrate and conditions indicated.
   5. Thickness: 1 1/4 inches.

B. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch; or coarse sand as recommended by underlayment manufacturer.
   1. Provide aggregate when recommended in writing by underlayment manufacturer for underlayment thickness required.

C. Water: Potable and at a temperature of not more than 70 deg F.

2.2 ACCESSORIES

A. Latex modified cement based floor patch product:
   1. Chapco Patch; H.B. Fuller Construction Products Inc.

B. Sealer: As recommended by manufacturer for the installation of resilient flooring.

C. Sound Deadening Pad: Entangled polymeric filament mat
   1. Product: Acousti Mat Premium II as manufactured by the Maxxon Corporation
      a. Thickness: 1/4 inches
      b. Locations: Refer to Finish Schedule.

D. Primer: Product of underlayment manufacturer recommended in writing for substrate, conditions, and application indicated.

PART 3 - EXECUTION

3.1 PREPARATION

A. General: Prepare and clean substrate according to manufacturer's written instructions.
   1. Treat nonmoving substrate cracks to prevent cracks from telegraphing (reflecting) through underlayment.
   2. Fill substrate voids to prevent underlayment from leaking.

B. Concrete Substrates: Mechanically remove laitance, glaze, efflorescence, curing compounds, form-release agents, dust, dirt, grease, oil, and other contaminants that might impair underlayment bond.
   1. Moisture Testing: Perform anhydrous calcium chloride test, ASTM F 1869. Proceed with installation only after substrates do not exceed a maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. in 24 hours.

C. Wood Substrates: Mechanically fasten loose boards and panels to eliminate substrate movement and squeaks. Sand to remove coatings that might impair underlayment bond and remove sanding dust.

D. Nonporous Substrates: For ceramic tile, quarry tile, and terrazzo substrates, remove waxes, sealants, and other contaminants that might impair underlayment bond, and prepare surfaces.

E. Adhesion Tests: After substrate preparation, test substrate for adhesion with underlayment.

3.2 APPLICATION

A. General: Mix and apply underlayment components according to manufacturer's written instructions.
   1. Close areas to traffic during underlayment application and for time period after application recommended in writing by manufacturer.
   2. Coordinate application of components to provide optimum underlayment-to-substrate and intercoat adhesion.
   3. At substrate expansion, isolation, and other moving joints, allow joint of same width to continue through underlayment.
   4. Contractor shall ventilate the buildings during the curing process of the underlayment.

B. Apply primer over prepared substrate at manufacturer's recommended spreading rate.

C. Apply underlayment to produce uniform, level surface.
   1. Apply a final layer without aggregate to product surface.
   2. Feather edges to match adjacent floor elevations.

D. Cure underlayment. Prevent contamination during application and curing processes.

E. Do not install floor coverings over underlayment until after time period recommended in writing by underlayment manufacturer.

F. Remove and replace underlayment areas that evidence lack of bond with substrate, including areas that emit a "hollow" sound when tapped.

G. Trowel on latex modified floor patch over underlayment at all locations where vinyl flooring is to be installed, refer to Drawings. In thickness as recommended by manufacturer.

H. For installation of adhered finishes over the underlayment refer to manufacturers recommendations for floor preparation.

END OF SECTION 035413

SECTION 03 6000
GROUTING

PART 1 - GENERAL

1.01 SUMMARY

A. The following types of grout are covered in this Section:

1. Non-Shrink Grout: This type of grout is to be used for applications hereinafter specified or where grout is shown on the Drawings, unless another type is specifically referenced.
2. Epoxy Grout: This type of grout is to be used for applications hereinafter specified or wherever epoxy grout is shown on the Drawings.

1.02 REFERENCES

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

1. ASTM C 109 – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 inch or 50 mm Cube Specimens)
2. ASTM C 191 – Standard Test Method for Time of Setting of Hydraulic Cement by Vicat Needle
3. ASTM C 230 – Standard Specification for Flow Table for use in Tests of Hydraulic Cement
4. ASTM C 531 – Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts and Monolithic Surfacings.
5. ASTM C 579 – Test Methods for Compressive Strengths of Chemical-Resistant Mortars and Monolithic Surfacings
6. ASTM C 827 – Standard Test Method for Early Volume Change of Cementitious Mixtures
7. ASTM C 696 – Test Method for Coefficient of Linear Thermal Expansion of Plastics
8. ASTM C 827 – Standard Test Method for Change in Height at Early Stages of Cylindrical Specimens from Cementitious Mixtures
9. ASTM C 939 – Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
10. ASTM 942 – Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory
11. ASTM C-1107 – Standard Specification for Packaged Dry, Hydraulic Cement Grout (Nonshrink)

B. U.S. Army Corps of Engineers (USACE):

1. CRD-C 621-82B – Corps of Engineers Specification for Non-shrink Grout

1.03 SUBMITTALS

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

1.04 QUALITY CONTROL

A. Perform field sampling and compression tests in accordance with the following provisions:

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 Architect to ensure continued compliance with these Specifications.

2. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C 109 at intervals during construction as selected by the Architect. Set of three specimens shall be made for testing at 7 days, 28 days, and each additional time period as appropriate.
3. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C 579, Method B, at intervals during construction as selected by the Architect. Set of three specimens will be made for testing at 7 days, and each earlier time period as appropriate.
4. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at the cost of the Contractor.
5. The cost of all laboratory tests on grout will be borne by the Owner, but the Contractor shall assist the Owner in obtaining specimens for testing. Contractor shall be charged for the cost of additional tests and investigation work performed which does not meet the Specifications. Contractor shall supply all materials necessary for fabricating the test specimens.

PART 2 - PRODUCTS

2.01 PREPACKAGED GROUTS

A. Non-shrink grout:

1. Non-shrink grout shall be a pre-packaged, inorganic, non-gas liberating, non-metallic, cement-based grout requiring only the addition of water. Manufacturer's instructions shall be printed on each bag or other container in which the materials are packaged. The specific formulation for each class of non-shrink grout specified herein shall be that recommended by the manufacturer for the particular application.
2. Class A non-shrink grouts shall have a minimum 28 day compressive strength of 6,000 psi; shall have no shrinkage (0.0 percent) and a maximum of 4.0 percent expansion in the plastic state when tested in accordance with ASTM C 827; and shall have no shrinkage (0.0 percent) and a maximum of 0.2 percent expansion in the hardened state when tested in accordance with CRD C 621.
3. Class B non-shrink grouts shall have a minimum 28 day compressive strength of 6,000 psi and shall meet the requirements of CRD C 621.
4. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

    a. US SPEC MP Grout
    b. SikaGrout 212
    c. Masterflow 928

B. Epoxy grout:

1. Epoxy grout shall be a pourable, non-shrink, 100 percent solids system. The epoxy grout system shall have three components: resin, hardener, and specially blended aggregate, all premeasured and prepackaged. The resin component shall not contain any non-reactive diluents. Resins containing butyl glycidyl ether (BGE) or other highly volatile and hazardous reactive diluents are not acceptable. Variation of component ratios to alter yield is not permitted unless specifically recommended by the manufacturer and approved by the ENGINEER. Manufacturer's instructions shall be printed on each container in which the materials are packaged.
2. The chemical formulation of the epoxy grout shall be that recommended by the manufacturer for the particular application.
3. The mixed epoxy grout system shall have a minimum working life of 45 minutes at 75° F.
4. The epoxy grout shall develop a compressive strength of 5,000 psi in 24 hours and 10,000 psi in seven days when tested in accordance with ASTM C 579, Method B. There shall be no shrinkage (0.0 percent) and a maximum 4.0 percent expansion when tested in accordance with ASTM C 827.
5. The epoxy grout shall exhibit a minimum effective bearing area of 95 percent. This shall be determined by a test consisting of filling a 2 inch diameter by 4 inch high metal cylinder mold covered with a glass plate coated with a release agent. A weight shall be placed on the glass plate.

At 24 hours after casting, the weight and plate shall be removed and the area in plan of all voids measured. The surface of the grout shall be probed with a sharp instrument to locate all voids.

6. The peak exotherm of a 2 inch diameter by 4 inch high cylinder shall not exceed 95° F when tested with a 75° F material at laboratory temperature. The epoxy grout shall exhibit a maximum thermal coefficient of 30 x 10-6 inches/inch/degree F when tested in accordance with ASTM C 531 or ASTM D 696.
7. Epoxy grout shall be used to embed those anchor bolts and reinforcing steel required to be set in grout, and for all other applications not addressed in Section 03 3000 – Cast-in-place Concrete.
8. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

    a. US SPEC EPG 2000
    b. Sikadur 42 Grout Pak
    c. Masterflow Brutem 19

2.02 CURING MATERIALS

A. Curing materials shall be as specified in the Section 03 3000 – Cast-in-Place Concrete, and as recommended by the manufacturer of prepackaged grouts.

2.03 CONSISTENCY

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

2.04 MEASUREMENT OF COMPONENTS

A. Prepackaged grouts shall have the components measured by means recommended by the manufacturer.

PART 3 - EXECUTION

3.01 GENERAL

A. All surface preparation, curing and protection of cement grout shall be as specified in Division 3 Section “Cast-in-Place Concrete.” The finish of the grout surface shall match that of the adjacent concrete.

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

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.

3.02 CONSOLIDATION

A. Grout shall be placed in such a manner, for the consistency necessary for each application, so as to assure that the space to be grouted is completely filled in order to ensure adequate baseplate bearing surfaces.

END OF SECTION