03 10 00– CONCRETE FORMING AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division - 01 Specification sections, apply to work of this section.

1.2 DESCRIPTION OF WORK

A. The work of this section includes all labor, materials and equipment required to form all cast-in-place concrete shown on the drawings including but not limited to all slabs, joists, beams, columns, walls, stairs, and equipment pads.

1.3 CODES AND STANDARDS

A. Comply with the provision of the current version of the following codes, specifications and standards except where more stringent requirements are shown or specified:

1. ACI 301 "Specifications for Structural Concrete for Buildings"

2. ACI 318 "Building Code Requirements for Reinforced Concrete"

3. ACI 117 "Specifications for Tolerances for Concrete Construction and Materials".

4. Concrete Reinforcing Steel Institute " Manual of Standard Practice"

1.4 RESPONSIBILITY

A. The design, construction and safety of all formwork shall be the responsibility of the General Contractor. All forms, shores, backshores, falsework, bracing, and other temporary supports shall be engineered to support all loads imposed including the wet weight of concrete, construction equipment, live loads, lateral loads due to wind and wet concrete imbalance. The Contractor shall also be responsible for determining when temporary supports, shores, backshores, and other bracing may be safely removed.

1.5 ENVIRONMENTAL OBJECTIVES

A. The Owner has established environmental goals and strategies for achieving them for this project based upon the LEED® Green Building Rating System for New Construction & Major Renovations Version 2009, as developed by the U.S. Green Building Council. Refer to Division 01 Section "Sustainable Design Requirements."

B. Manufacturer to supply documentation of level of compliance or non-compliance with the following requirements before consideration as an "acceptable manufacturer:"

1. The following are mandatory requirements for the overall project:

a. The material(s) in the product(s) supplied should have a recycled content such that the sum of the post-consumer recycled content plus one-half of

the pre-consumer content constitutes at least «percentage of required recycled material»% of the total value of the material in the project.

b. percentage of close proximity material»% of the product(s) supplied is extracted, processed, and manufactured regionally within a radius of 500 miles of this Project.

c. Paints and coatings must meet or exceed the VOC and chemical component limits of Green Seal requirements.

d. The VOC content of adhesives and sealants must be less than the current VOC content limits of South Coast Air Quality Management District (SCAQMD) Rule #1113, Architectural Coatings, rules in effect on July 13, 2007.

C. Products that conform to requirements of the Environmental Objectives yet do not fully meet other requirements of this Section may still be considered for use at the sole discretion of the Owner and Architect.

1.6 DESIGN RESPONSIBILITY

A. The design of all concrete formwork, formwork removal, shoring, and backshoring requirements shall be performed by a registered professional engineer in the state of Texas and experienced in the design of concrete formwork. The Contractor shall employ the formwork engineer. Calculations, sealed by the registered professional engineer, shall be issued for Owner's record but will not be reviewed or returned.

1.7 SUBMITTALS

A. Design Calculations: Submit for record calculations of all concrete formwork and the shoring plan sealed by a registered engineer in the state of Texas.

B. Formwork Drawings: Formwork Drawings, prepared under the supervision and sealed by a registered professional engineer in the state of Texas, shall be submitted for Owners record and shall be reviewed by the Engineer for conformance to structural layout only. Such shop drawings shall indicate types of materials, sizes, lengths, connection details, design allowance for construction loads, anchors, form ties, shores, braces, construction joints, reveals, camber, openings, formwork coatings and all other pertinent information.

C. Pan Form Shop Drawings: The Contractor shall submit pan shop drawings for Engineer's review and approval. Approval will be for conformance to structural layout only.

D. Shoring Plan: Submit drawings to indicate the number of levels of shoring, proposed time and sequence of formwork and shore removal, minimum concrete strength for stripping of forms and shore removal, assumed construction loads, amount and layout of shores (specify whether backshores or reshores), and length of time shores are to be left in place. This plan shall be strictly followed by the Contractor. Shoring plans are to be submitted for Owner's record and reviewed for impact to structure.

E. LEED Submittals (Projects authorized for LEED certification only)

1. Recycled Content- Credit MR4.1/MR 4.2: Provide documentation indicating percentages of post-consumer and pre-consumer recycled content by weight per unit of product or assembly containing the product. Indicate the percentage of the dollar value of the recycled content compared to the total dollar value of the product or assembly containing the product.

2. Material Proximity- Credit MR 5.1/MR 5.2: Where the distances to the project site is 500 miles or less, indicate location and distance to project site of extraction, harvesting, recovery and manufacturing of all materials. Indicate the dollar value of the material cost of the product containing local/regional materials. Where product components are sourced or manufactured in separate locations, provide location and percentage by weight of each component per unit of product.

PART 2 - PRODUCTS

2.1 PAN FORMS

A. Specification: Unless specified otherwise, concrete joist construction shall conform to current version of Manual of Standard Practice, Chapter 10, as published by CRSI.

B. Material and Pan Type:

1. Material: Pans shall be fabricated either of steel that is free of dents, irregularities, sag and rust or of glass-fiber reinforced plastic that is molded under pressure with matched dies. Pan forms allowing warped surfaces, leakage of concrete at joints, and uneven surfaces beyond tolerance levels will not be acceptable.

2. Subject to pan tolerance and the surface finish required by the surface finish class SF-1.0 as shown on the drawings, pan forms may be either new pans or reconditioned pans at Contractor's option. Forms may be "long forms", "flange forms", "long flange forms", or "adjustable forms" at Contractor's option. Pan splices may be lapped, reinforced butt jointed, or semi-butt jointed (using end caps welded back-to-back with 2" maximum distance between pan ends). The maximum number of joints in any bay shall be four located at approximately the one-fifth points in each bay.

3. Subject to pan tolerance and the surface finish required by the surface finish class SF-1.1 as shown on the drawings, pan forms in exposed areas shall be new pans and pan forms in unexposed areas may be reconditioned pans. Forms may be "long forms", "flange forms", "long flange forms", or "adjustable forms" at Contractor's option. Pan splices may be lapped, reinforced butt jointed, or semi-butt jointed (using end caps welded back-to-back with 2" maximum distance between pan ends). The maximum number of joints in any bay shall be four located at approximately the one-fifth points in each bay.

4. New Pans. All pan forms used in areas designated to have Surface Finish-2.3 shall be new pans either one piece continuous from beam to beam or beam to header ("longforms", "long flange forms", or "adjustable forms") without splices or with reinforced butt joint spliced. "Flange forms" are not acceptable, nor will forms be permitted that are lapped spliced or semi-butt joint spliced (using end caps welded back-to-back). Pans shall meet tolerances and the surface finish required for surface finish class 2.3.

5. New Pans. All pan forms used in areas designated to have Surface Finish-3.3 shall be new pans either one piece continuous from beam to beam or beam to header ("longforms", "long flange forms", or "adjustable forms") without splices or reinforced butt joint spliced. "Flange forms" are not acceptable, nor will forms be permitted that are lapped spliced or semi-butt joint spliced (using end caps

welded back-to-back). Pans shall meet tolerances and the surface finish required for surface finish class 3.3.

The pan form surfaces specified herein are intended to be architecturally

2.2 FORM-FACING MATERIALS

A. Smooth-Formed Finished Concrete: Unless otherwise specified, formwork for exposed concrete surfaces as defined by the Surface Finish Class noted on the drawings, shall consist of plywood, metal, metal framed plywood, or other acceptable surface. Formwork shall provide a continuous straight and smooth surface conforming to the joint system as specified on the Architect's drawings. Form material shall have sufficient thickness to withstand pressure of concrete without bow or deflection. Plywood shall be exterior grade plywood panels, suitable for concrete forms, complying with U.S. Product Standard PS-1, each piece bearing a legible inspection trademark, and as follows:

1. Phenolic Surface Film Overlay over Hardwood Face, Class 1 or better.

2. High Density Overlay (100/30 min. rating) on Hardwood Face, Class 1or better.

3. High Density Overlay (100/30 min. rating) on Softwood Face, Class 1 or better

4. Medium Density Overlay on Hardwood Face,Class 1 or better, mill-release agent treated and edge sealed.

5. Medium Density Overlay on Softwood Face, Class 1 or better, mill-release agent treated and edge sealed.

6. Structural 1, B-B, or better, mill oiled and edged sealed.

7. "B-B (Concrete Form) Plywood", Class 1, or better, mill-oiled and edge sealed.

B. Non-specific formed concrete: Unless otherwise specified, the default finish for formed surfaces shall be rough-form finish constructed with plywood, lumber, metal or other acceptable material. Lumber shall be dressed on at least two edges and one side for tight fit. The minimum grade shall be B-C, exterior grade.

C. Textured-form finished concrete: For exposed surfaces as noted on the drawings provide units of form face design, size, arrangement and configuration that matches Architect's control sample. Provide solid backing and form supports to ensure stability of textured form liners. See Architect's drawings, specifications and control sample for special form textured finish concrete.

2.3 CYLINDRICAL COLUMNS AND SUPPORTS

A. Round section members shall be formed with metal or fiberglass, unless otherwise specified. Units shall have sufficient wall thickness to resist loads imposed by wet concrete without detrimental deformation.

2.4 FORMWORK COATINGS

A. Formwork coatings shall be a commercial formulation that will not bond with, stain, nor adversely affect concrete surfaces or impair subsequent treatment of concrete surfaces requiring bond or adhesion, nor impede curing with water or curing compounds. Provide a product that has a maximum VOC (Volatile Organic Compounds) of 50 g/l but not

greater than that permitted by the local government agency having jurisdiction in the area where the project is located.

Products: Subject to compliance with requirements, provide one of the following:

"Bio-Release EF", Dayton Superior
"Farm Fresh", Unitex
"Form-Eze Natural", The Euclid Chemical Company, Inc.
"Bio-Form", Universal Form Clamp
"Aqua Blue", US Spec

2.5 NAILS AND FASTENERS

A. Use only galvanized nails and fasteners for securing formwork in structures exposed to weather or unconditioned spaces such as garages, canopies and porte-cocheres.

2.6 FORM TIES

A. Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to minimize spalling of concrete on removal.

1. Exposed Surfaces: For surfaces designated with Surface Finish Class SF-2.x or SF-3.x , furnish units that will leave no portion of the tie closer than 3/4 inch to the plane of the concrete surface and that will leave holes not larger than 1 inch in diameter in concrete surface when the ends or end-fasteners have been removed.

2. Dampproofed Surfaces: Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

3. Exposed to Weather or Unconditioned Space: Provide removable, glass-fiber-reinforced plastic, stainless steel, or galvanized form ties that will leave no corrodible metal closer than 1 1/2 inches in surfaces that will be exposed to weather or in an unconditioned space in the final structure. The ties shall leave holes no larger than 1 inch in diameter in concrete surfaces when the ends or end-fasteners are removed.

2.7 CHAMFER STRIPS

A. Provide wood, metal, PVC, or rubber strips, ¾ by ¾ inch, minimum.

PART 3 - EXECUTION

3.1 FABRICATION AND CONSTRUCTION

A. Design, erect, support, brace and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic construction loads that might be applied until the concrete structure can support such loads.

B. Construct forms to sizes, shapes, lines and dimensions shown, and to obtain accurate alignment, location, grades, level and plumb work in finished structures. Provide for openings, offsets, sinkages, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts and other features

required in work. Use selected materials to obtain required finishes. Solidly butt joints and provide back-up at joints to prevent leakage of cement paste.

C. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood inserts for forming keyways, reglets, recesses, and the like, to prevent swelling and for easy removal.

D. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

E. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Securely brace temporary openings and patch forms to prevent loss of concrete mortar. Locate temporary openings on forms at inconspicuous locations.

F. Chamfer exposed corners and edges as indicated, using specified chamfer strips fabricated to produce uniform smooth lines and tight edge joints.

G. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Coordinate size and location of openings, recesses and chases from trades providing such items. Accurately place and securely support items built into forms.

H. Pan Form Fabrication and Construction:

1. Factory fabricate pan form units to specified sizes and shapes as indicated on the drawings. Units shall be designed for easy removal without damaging placed concrete. Units shall be properly shored and adjoining pan units shall be blocked if required to prevent lateral or vertical deflection of formwork during concrete placement.

2. Load Distribution Ribs: Provide load distribution ribs at least 5" wide for all pans 30" wide and narrower and elsewhere where indicated on the drawings. Minimum rib spacing shall be:

   a. None in spans less than 20 feet.
   b. One near the center of spans 20 to 30 feet.
   c. Two near the third points of spans over 30 feet.

   Discontinue ribs between two adjacent joists or beams that have differences in span larger than 33%, between a joist and an adjacent parallel wall, and between a joist and an adjacent parallel beam that is 1 ½ or more times wider than the joist.

3.2 CLEANING AND TIGHTENING

A. Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and all other debris just prior to concrete placement. Retighten forms and bracing prior to concrete placement as required to prevent mortar leaks and maintain proper alignment.

3.3 CLEANING AND RE-USE OF FORMS

A. Forms reused in the work shall be repaired and cleaned. Split, frayed, delaminated, or otherwise damaged facing material will not be acceptable for exposed surfaces. Forms intended for successive concrete placement shall have surfaces cleaned, fins and laitance removed, and joints tightened to avoid surface offsets. New form coating compound shall be applied to reused forms. Thin form-coating compounds only with thinning agent of type, and in amount, and under conditions of form-coating compound manufacturer's directions. Do not allow excess form-coating material to accumulate in forms or to come into contact with in-place concrete surfaces against which fresh concrete will be placed. Apply in compliance with manufacturer's instructions. Coat steel forms with a non-staining, rust-preventative form oil or otherwise protect against rusting. Rust-stained steel formwork is not acceptable.

3.4 TOLERANCES

A. Unless specified otherwise, all tolerances for concrete formwork shall conform to ACI Standard 117, "Standard Tolerances for Concrete Construction and Materials". Before concrete placement the Contractor shall check lines and levels of erected formwork and make any corrections and adjustments as required to ensure proper size and location of concrete members and stability of forming systems. During concrete placement the Contractor shall check formwork and supports to ensure that forms have not displaced and that completed work will be within specified tolerances.

B. Construct forms so as to limit the offset between adjacent pieces of formwork facing material in accordance with the surface tolerance class as defined in ACI 117 corresponding to the surface finish class noted on the drawings. The offset limits shall apply to both abrupt and gradual variations in the surface.

C. Pan Construction Surface Tolerance: Discontinuities in the concrete surface formed by pan construction shall be limited to the values noted in the surface tolerance classes of ACI 117 corresponding to the surface finish classes noted on the drawings.

D. Prior to each concrete pour, the Contractor shall engage a qualified surveyor to verify that work is within specified tolerances.

3.5 SHORES AND SUPPORTS

A. Definitions

1. Shores: Vertical or inclined support members designed to carry the weight of formwork, concrete, and construction loads above.

2. Reshores: Shores placed snugly under a stripped concrete structural member after the original forms and shores have been removed from the member, thus requiring the member to carry its own weight and superimposed construction loads at the time of installation. Reshores are assumed to carry no load at the time of installation. After the installation of reshores, superimposed construction loads are assumed to be distributed among all members connected by reshores.

3. Backshores: Shores placed snugly under a stripped concrete structural member after the original formwork and shores have been removed from a small area without allowing the structural member to deflect or support its own weight

or superimposed construction loads. It is assumed that backshores carry the same load as that carried by the original shores they replace.

Comply with requirements of ACI 301 for shoring, reshoring and backshoring in concrete construction and as herein specified where more stringent.

B. Design: Shores and reshores or backshores must be designed to carry all loads transmitted to them. A rational analysis should be used to determine the number of floors to be shored, reshored, or backshored, subject to the minimums stated in the following paragraph, and to determine the loads transmitted to the floors, shores and reshores or backshores as a result of the construction sequence. The analysis should consider, but should not necessarily be limited to, the following:

1. Structural design load of the slab or member including live load, partition loads, and other loads for which the engineer designed the slab. The live load reduction factors for the design of certain members are shown on the structural drawings. The reduced live load and an allowance for construction loads shall be taken into consideration when performing the analysis.

2. Dead load weight of the concrete and formwork.

3. Construction live loads, such as placing crews and equipment or stored materials.

4. Design strength of concrete specified.

5. Cycle time between placement of successive floors.

6. Strength of concrete at time it is required to support shoring loads from above.

7. The distribution of loads between floors, shores, and reshores or backshores at the time of placing concrete, stripping formwork, and removal of reshoring or backshoring.

8. Span of slab or structural member between permanent supports.

9. Type of formwork systems, i.e., span of horizontal formwork components, individual shore loads, etc.

10. Minimum age where appropriate.

11. Alignment of shores. Where possible, Shores for any floor shall be placed directly above previously placed shores so that load will be transferred directly to such shores.

3.6 REMOVAL OF FORMS AND SUPPORTS

A. Determination by Contractor's Registered Engineer: The Contractor's registered engineer shall determine and submit for Owner's record the time and sequence of formwork and shore removal subject to the criteria as specified below. The submittal shall clearly distinguish between reshoring and backshoring procedures.

B. Determining *in situ* Strength of Concrete: The General Contractor shall be responsible for making and curing concrete cylinders, cured under field conditions, for the purpose of determining concrete strength at time of form and shore removal. Such cylinders shall be

made by the Contractor and tested by his testing laboratory. Alternatively, the *in situ* strength of concrete may be determined by the Maturity Method following the requirements of ASTM C 1074. An acceptable system for this method is the "*intelli*Rock" system manufactured and supplied by Engius Constructive Intelligence of Stillwater, OK.

C. Records of Weather Conditions: The General Contractor shall be responsible for keeping records of weather conditions to be used in the decision on when to remove forms.

D. Formwork Not Supporting Concrete: Formwork not supporting concrete such as sides of beams, walls, columns and similar parts of the structure, may be removed after cumulatively (not necessarily consecutively) curing at a concrete temperature not less than 50°F for 12 hours after placing concrete, provided the concrete is sufficiently hard so as not to be damaged by form removal operations and provided curing and protection operations are maintained. If ambient air temperatures remain below 50°F, if retarding agents are used, or if Type II and Type V Portland cement is used, then this specified minimum period should be increased as required to safely remove the forms without damage to the concrete. Where such forms also support formwork for slab or beam soffits, the removal times of the latter shall govern.

E. Formwork Supporting Weight of Concrete: Formwork supporting weight of concrete such as beam soffits, joists, slabs and other structural elements shall not be removed until concrete has attained at least the following percentages of the design compressive strength, while cured following the specified requirements, including hot or cold-weather concreting, where applicable:

Joists, Beam Bottoms	- 70%, but not less than 2800 psi
Slabs	- 70%, but not less than 2800 psi

F. Placing Reshores and Backshores:

1. All shoring operations shall be carried out in accordance with a planned sequence as determined by the Contractor's shoring engineer.

2. Shoring operations shall be performed so that at no time will areas of new construction be required to support combined dead and construction loads in excess of the available strength as determined by the design loads (as specified in the General Notes) and the developed concrete strength (as determined by field cured cylinders) at the time of stripping and reshoring or backshoring.

3. Shores (backshores or reshores) shall not be removed until the structural member supported has sufficient strength to support all applied loads.

4. For backshoring operations, the forms shall be removed in such a manner that individual structural members are not allowed to deflect and carry load.

5. Reshoring operations require that the structural members be strong enough to safely support their own weight before stripping of formwork.

6. For reshoring operations, no structural member shall be overstressed under its own dead weight plus the weight of the floors above and construction loads assigned to the structural member by a rational analysis that accounts for the relative stiffness of each floor with due consideration of concrete age and strength. While reshoring is underway, no construction loads shall be permitted on the new construction unless it can safely support the construction loads.

7. Where possible, shores shall be located in the same position on each floor so that they will be continuous in their support from floor to floor.

G. Post Tension Construction: Formwork supporting post-tensioned floor construction, including shores, reshores and backshores shall be designed to support any additional loads produced by the stressing operation.

END OF SECTION 03 10 00

SECTION 03 20 00 – CONCRETE REINFORCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections apply to work of this section.

1.2 DESCRIPTION OF WORK

A. The work of this section includes labor, materials, hardware, equipment, transportation and services required to fabricate and place all reinforcement for cast-in-place concrete including bars, welded wire fabric, ties and supports shown on the drawings and as specified. Prestressing reinforcement is specified in Post-Tensioned Concrete and/or Precast Concrete sections of the specifications.

1.3 ENVIRONMENTAL OBJECTIVES

A. The Owner has established environmental goals and strategies for achieving them for this project based upon the LEED® Green Building Rating System for New Construction & Major Renovations Version 2009, as developed by the U.S. Green Building Council. Refer to Division 01 Section "Sustainable Design Requirements."

B. Manufacturer to supply documentation of level of compliance or non-compliance with the following requirements before consideration as an "acceptable manufacturer:"

1. The following are mandatory requirements for the overall project:

a. The material(s) in the product(s) supplied shall have a recycled content such that the sum of the post-consumer recycled content plus one-half of the pre-consumer content constitutes at least [Percentage of required recycled materials]% of the total value of the material in the project.

b. [Percentage of close proximity material]% of the product(s) supplied is extracted, processed, and manufactured regionally within a radius of 500 miles of this project.

1.4 QUALITY CONTROL

A. The Contractor is responsible for management of quality control on the project, including verification of the compliance of the workmanship and materials furnished by his subcontractors and suppliers.

B. Codes and Standards: Comply with all provisions of the following codes, specifications and standards except where more stringent requirements are shown or specified:

1. ACI 301 - "Specifications for Structural Concrete for Buildings".

2. ACI 117 - 'Specifications for Tolerances for Concrete Construction and Materials."

3. Concrete Reinforcing Steel Institute (CRSI), "Manual of Standard Practice".

4. ANSI/AWS D1.4 “Structural Welding Code – Reinforcing Steel”

1.5 SUBMITTALS

A. Shop Drawings: Submit shop drawings for all reinforcing steel and related accessories for the Engineer's approval. Shop drawings shall show arrangement and layout, bending and assembly diagrams, bar schedules, stirrup spacing, splicing of bars, laps of bars, and layout/configuration of all necessary miscellaneous support bars in accordance with CRSI Standards.

B. Mill Certificates: Submit, for record, mill certificates and/or test results signed by Contractor and Producer, for all reinforcement.

C. Product Data: Submit manufacturer's product data with application and installation instructions for proprietary materials and items, including mechanical splices, hooked anchorage systems, large-headed stud punching shear reinforcement, dowel bar substitute systems, and dowel bar sleeves.

D. International Code Council (ICC) Evaluation Service Reports: Submit evaluation service reports of approval from ICC Evaluation Service, Inc. for mechanical splice, hooked anchorage systems, large-headed stud punching shear reinforcement and dowel bar substitute systems.

E. LEED Submittals (Projects authorized for LEED certification only)

1. Recycled Content- Credit MR4.1/MR 4.2: Provide documentation indicating percentages of post-consumer and pre-consumer recycled content by weight per unit of product or assembly containing the product. Indicate the percentage of the dollar value of the recycled content compared to the total dollar value of the product or assembly containing the product.

2. Material Proximity- Credit MR 5.1/MR 5.2: Where the distance to the project site is 500 miles or less, indicate location and distance to project site of extraction, harvesting, recovery and manufacturing of all materials. Indicate the dollar value of the material cost of the product containing local/regional materials. Where product components are sourced or manufactured in separate locations, provide location and percentage by weight of each component per unit of product.

1.6 PREINSTALLATION CONFERENCE

A. The Reinforcing-Placing subcontractor shall attend the Pre-Concrete Conference conducted by the Concrete Contractor as described in Specification Section "Cast-in-Place Concrete".

1.7 TESTING AND INSPECTION

A. In advance of fabrication and shipment to the project, the fabricator shall have performed all tests and inspections of reinforcing steel as specified herein.

B. Any testing laboratory retained to run tests required by this specification shall meet the basic requirements of ASTM E 329.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Reinforcement:

1. Reinforcing materials shall be delivered from the mill in bundles that are identified as to heat number and manufacturer and accompanied with mill and analysis test reports and an affidavit from the fabricator/supplier stating that the material conforms to the requirements of the governing ASTM specification listed herein.

2. Deformed bar material that is not identifiable according to the criteria listed above shall be tested for tensile strength and bend tests according to ASTM A 615 on a sample of 2 bars for each ten tons or fraction thereof of unidentified material for each bar size. The bars shall be a minimum of 24 inches long. Bend tests are not required for #14 and # 18 bars. Fabricator/supplier shall submit the results of such tests for record.

3. Reinforcing Bars: Reinforcing bars shall conform to ASTM A 615, Grade 75 as noted on the drawings.

4. Reinforcing Bars: Reinforcing bars shall conform to ASTM A 615 Grade 60 as noted on the drawings.

5. Special Requirements for Grade 60 Reinforcing Bars: ASTM A 615 Grade 60 Reinforcing bars used as longitudinal reinforcing in locations as noted on the drawings shall additionally comply with the following requirements.

    a. The actual yield strength based on mill tests shall not exceed the nominal yield strength f_y by more than 18,000 psi.
    b. The ratio of the actual tensile strength to the actual yield strength is not less than 1.25.

6. Reinforcing Bars: Reinforcing bars used as longitudinal reinforcing in locations as noted on the drawings shall conform to ASTM A 706.

7. Reinforcing Steel: Reinforcing steel used as transverse reinforcing or as spiral reinforcing as noted on the drawings shall conform to ASTM A 1035.

8. Weldable Reinforcing Bars: All reinforcing bars noted on the drawings as being required to be welded shall conform to ASTM A 706.

9. Galvanized Reinforcing Steel: Provide galvanized reinforcing bars at the locations indicated on the drawings. Galvanized reinforcing bars shall conform to ASTM A 767 Class II (2.0 oz. zinc PSF), hot dipped galvanized after fabrication and bending. Bars that are to be galvanized shall conform to the type of steel required for the given situation as noted on the drawings.

10. Epoxy-Coated Reinforcing Steel: Provide epoxy coated reinforcing bars at the locations indicated on the drawings. Epoxy coated reinforcing bars shall conform to ASTM A 775. Bars that are to be epoxy coated shall conform to the type of steel required for the given situation as noted on the drawings.

11. Epoxy-Coated Fabricated Reinforcing Steel: Provide reinforcing bars that are epoxy-coated after fabrication at the locations indicated on the drawings. Reinforcing bars that are epoxy-coated after fabrication shall conform to ASTM A 934. Bars that are to be epoxy-coated shall conform to the type of steel required for the given situation as noted on the drawings.

12. Use Reinforcing steel made from 90% recycled material, 2/3 of which shall be post-consumer material. A minimum of 50% of the material in the reinforcement

must have been extracted, harvested, or recovered as well as manufactured, within 500 miles of the project site.

13. Plain Steel Welded Wire Reinforcement: ASTM A 185 with a yield strength of 65,000 PSI. Provide in flat sheets only.

14. Deformed-Steel Welded Wire Reinforcement: ASTM A 497 with a yield strength of 70,000 PSI. Provide in flat sheets only.

15. Galvanized Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from galvanized steel wire into flat sheets.

16. Epoxy Coated Plain-Steel Welded Wire Reinforcement: ASTM A 884, Class A, plain steel.

17. Epoxy Coated Deformed-Steel Welded Wire Reinforcement: ASTM A 884, Class A, deformed steel.

18. Strands: Uncoated seven wire, one half inch diameter, stress relieved 270 ksi strand low relaxation type, ASTM A 416 "Specification for Uncoated Seven Wire Stress Relieved Strand for Prestressed Concrete" and "Specification for Unbonded Single Strand Tendons" as published by the Post-Tensioning Institute.

19. Prestressing Bars: All prestressing bars shall be deformed threadbars conforming to ASTM A 722 "Specification for Uncoated High Strength Steel Bar for Prestressing Concrete", with a minimum ultimate tensile strength of 150 KSI and other properties as specified on page 11-21 of the PCI Design Handbook, fifth edition. Threadbars, plate anchorages and couplings shall be furnished by Dywidag Systems International or Williams unless approved otherwise in writing by the Engineer.

20. Wire: Smooth wire for spiral reinforcement shall conform to ASTM A 82 with a minimum yield strength of 70,000 PSI.

21. Epoxy-Coated Plain-Steel Wire: ASTM A 884,Class A, plain-steel wire.

22. Joint Dowel Bars: Smooth bars used to dowel across slab-on-grade construction joints shall conform to ASTM A 615, Grade 40 or ASTM A 36, plain-steel bars. Cut bars true to length with ends square and free of burrs

23. Epoxy-Coated Joint Dowel Bars: Smooth epoxy-coated bars used to dowel across slab-on-grade construction joints shall conform to ASTM A 775 with ASTM A 615, Grade 40 or ASTM A 36 plain-steel bars. Cut bars true to length with ends square and free of burrs.

24. Dowel Bar Sleeves: Plastic or gage metal (26 ga. min.) sleeves with an inside diameter of 1/16 inch greater than the dowel bar that it encases, that have the strength, durability, and design to provide free movement of the dowel relative to the concrete slab and that are specifically manufactured for this purpose.

25. Alternate Slab-on-Grade Joint Load Transfer Systems: A system that consists of flat, ASTM A 36 plate that is saw cut into a square or rectangular shape and is embedded into or encased by a plastic sleeve that allows movement in both lateral directions but not in the vertical direction. Acceptable systems are manufactured by PNA Construction Technologies with products known by the

names “Diamond Dowel System” and “PD^3 Basket” and Greenstreak Group Inc. with products known as “Speed Plate’ and “Double-Tapered Basket”.

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

    a. Tie wire in architecturally exposed concrete shall be plastic coated or stainless steel.
    b. Tie wire for epoxy-coated reinforcement shall be epoxy-coated.
    c. Tie wire for galvanized reinforcement shall be galvanized.

27. Headed Steel Stud Punching Shear Reinforcement: Punching shear reinforcement using headed studs welded to flat bars shall be manufactured in conformance with ASTM A1044 and approved by the ICC Evaluation Service, Inc. as expressed in an ICC Evaluation Report for use as punching shear reinforcement for slabs and footings designed in accordance with ACI 421.1. The following are acceptable products:

    “Decon Studrails”, Decon
    “Dayton Shear Resistance System (DSR) D-140”, Dayton Superior Corporation
    “Suncoast Stud Reinforcement System”, Suncoast Post-Tension, Ltd.

28. Supports for Reinforcement: Provide supports for reinforcement including bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcing bars and welded wire fabric in place. Use wire bar type supports complying with CRSI recommendations.

    a. Slabs-on-Grade: Use precast concrete bar supports (dobies) or supports with sand plates or horizontal runners designed for use on ground.
    b. Spread Footing Bottom Reinforcement: Use precast concrete bar supports (dobies) or chairs designed for soil-supported slabs.
    c. Mat Foundation: Use precast concrete bar supports (dobies), chairs designed for soil-supported slabs, or poured-in-place concrete curbs.
    d. Exposed to View Concrete: Provide supports with legs which are plastic protected stainless steel protected (CRSI, Class 2).
    e. Support of Epoxy-Coated Reinforcement: Provide epoxy-coated or other dielectric-polymer-coated wire bar supports to support epoxy-coated reinforcement.
    f. Support of Galvanized Reinforcement: When NOT exposed to view, provide galvanized wire bar supports to support galvanized reinforcement. In all exposed to view conditions provide supports with legs which are plastic protected stainless steel protected (CRSI, Class 2).

B. Coating Repair Materials: Repair damaged areas of epoxy-coated or galvanized reinforcement using the following products.

1. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating compatible with epoxy coating on reinforcement and complying with ASTM A 775.

2. Zinc Repair Material: ASTM A 780, zinc-based solder, paint containing zinc dust, or sprayed zinc shall be used to repair damaged areas of galvanized reinforcement.

2.2 SPLICES

A. End Bearing Compression Splices: Members with end bearing compression splices shall have vertical bars saw cut or otherwise finished for true bearing. Bar ends shall terminate in flat surfaces within 1 1/2 degrees of a right angle to the axis of the bars and shall be fitted within 3 degrees of full bearing after assembly. Splice bars shall be held in concentric contact by a suitable device. The following are acceptable end bearing compression devices:

"Speed Sleeve", Erico Products, Inc.
"G-Loc", BarSplice Products, Inc.
or other Engineer-approved product.

B. Mechanical Tension Splices:

1. Mechanical splices shall conform to Type 1 and Type 2 splices.

a. Type 1 splice shall develop 1.25 times the specified yield strength of the splice bar.
b. Type 2 splice shall meet the requirements of Type 1 splice and, in addition, develop the full tensile strength of the splice bar.

2. Splices shall be approved by the ICC-Evaluation Service, Inc and shall have the Evaluation Report submitted for Engineer review.

3. The bar ends that are to attach to the splice shall be prepared and installed in accordance with the manufacturer's requirements.

4. The following are acceptable mechanical tension splices (splices qualified for use with grade 75 bars are parenthetically noted):

"BarLock, S-Series", Dayton Superior.
"US/MC-SAE Mechanical Coupler", Dayton/Richmond, Inc.
"DB Grout Sleeve", Dayton/Richmond
"ZAP Screwlok", BarSplice Products, Inc. (qualified for use with grade 75 bars)
"BPI Grip XL System", Barsplice Products, Inc.
"Taper Threaded Grip Twist System", Barsplice Products, Inc.
"Lenton Coupler", Erico Products, Inc. (for grade 75 bars, use only "Standard Coupler")
"NMB Splice Sleeve", Splice Sleeve North America" (qualified for grade 75 #7 bars and higher)
"BarLock, L-Series", Dayton Superior
"Taperlok Couplers", Dayton Superior
"Lenton Interlok", Erico Products, Inc.
"Griptec", Dextra Manufacturing Co.
or other Engineer-approved product.

C. Dowel Bar Replacement: All grade 60 reinforcing steel dowel bars shown on the drawings crossing concrete construction joint surfaces with inserts cast flush against the form and having reinforcing bars connected to the insert in a subsequent concrete pour shall conform to the following:

1. Splice connection to the insert shall develop the 1.25 times the specified yield strength and the full tensile strength of the spliced bar.

2. Splices shall be approved by the ICC Evaluation Service, Inc. as expressed in an ICC Evaluation Service Report which shall be submitted for review.

3. The following are acceptable products (for use only with grade 60 bars):

"Lenton Form Saver", , Erico Products, Inc.
"DB-SAE Dowel Bar Splicer", Dayton/Richmond, Inc.
or other Engineer-approved product.

D. Hooked Anchorage Replacement: Reinforcing bar terminations shall be manufactured out of ASTM A 576 material and shall develop the full tensile strength of the bar when installed at the manufacturer's recommended depth.

1. The anchorage shall be approved by the ICC Evaluation Service Inc. as expressed in an ICC Evaluation Service Report which shall be submitted for review.

2. The following are acceptable products (for use only with grade 60 bars):

"Lenton Terminator", Erico Products, Inc.
or other Engineer-approved product.

PART 3 - EXECUTION

3.1 FABRICATION AND DELIVERY

A. Bending and Forming: Fabricate bars of indicated sizes and accurately form to shapes and lengths indicated and required, by methods not injurious to materials. Do not heat reinforcement for bending. Bars shall be free from injurious defects, have a workman-like finish with no excessive rust and/or pitting and have no unusual kinks or bends.

B. Marking and Shipping: Bundle reinforcement and tag in accordance with Section 7.4.5 of the CRSI "Manual of Standard Practice". Transport and store at site so as not to damage material. Keep sufficient supply of tested, approved and proper reinforcement at the site to avoid delays. Maintain reinforcing bars free of mud, dirt, grease, or other coating.

C. Repair of Epoxy-Coated Reinforcing: Repair cut and damaged epoxy coatings on fabricated reinforcing before delivery with epoxy repair coating according to ASTM D 3963

3.2 PLACING REINFORCEMENT

A. Comply with CRSI recommended practice for "Placing Reinforcing Bars", for details and methods of reinforcement placement and supports and as herein specified.

B. Before placing reinforcement and again before concrete is placed, clean reinforcement of loose rust and mill scale, earth, ice and other materials which reduce or destroy bond with concrete.

C. Accurately position, support and secure reinforcement against displacement by formwork, construction, or concrete placement operations. Locate and support reinforcing by chairs, runners, bolsters, spacers and hangers, as required. Exercise particular care to maintain proper distance and clearance between parallel bars and between bars and forms. Provide spreaders and spacers to hold steel in position. Support steel at proper height upon approved chairs.

D. Place reinforcement to obtain at least minimum coverages for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position

during concrete placement operations. Set tie wires so ends are directed into concrete, not toward exposed concrete surfaces.

E. Support of Spread Footing Reinforcing Steel

1. Bottom Steel: Support bottom reinforcing mat to provide the specified clearance to the bars. Spacing between supports shall not exceed 4'-0" centers each way.

2. Top Steel: Support top reinforcing on steel angle frames braced in both directions or on special standee support bars. Spacing between supports shall not exceed 4'-0" centers each way. The depth of the supports shall provide the specified clearance from the bars to the top of the concrete. The design of the support steel shall be the responsibility of the Contractor in accordance with Concrete Reinforcing Steel Institute (CRSI), “Manual of Standard Practice”.

F. Support of Mat Foundation Reinforcing Steel

1. Bottom Steel: Support bottom reinforcing mat to provide the specified clearance to the bars. Spacing between supports shall not exceed 4'-0" centers each way.

2. Top Steel: Support top reinforcing on steel angle frames braced in both directions or on special standee support bars. Spacing between supports shall not exceed 4'-0" centers each way. The depth of the supports shall provide the specified clearance from the bars to the top of the concrete. The design of the support steel shall be the responsibility of the Contractor in accordance with Concrete Reinforcing Steel Institute (CRSI), “Manual of Standard Practice”.

G. Install welded wire reinforcement in as long lengths as practicable. Lap adjoining pieces at least one full mesh plus two inches and lace splices with wire. Offset end laps in adjacent widths to prevent continuous laps in either direction.

H. Coordinate with other trades and expedite materials and labor to avoid omissions and delay.

I. Install waterproof membrane or vapor barrier as specified prior to placing steel for concrete slabs-on-grade.

J. Extend reinforcement continuous through construction joints unless otherwise shown on the drawings.

K. Slab-on-Grade Joint Dowel Bars: Support slab-on-grade joint dowel bars independently of support for slab reinforcement on soil supported slab bolsters or specially manufactured cradles such that dowel bar remains parallel to slab surface and at right angles to joint during concreting operations. Lightly coat the exposed end of the dowel with a paraffin-base lubricant, asphalt emulsion, form oil, or grease or use a dowel bar sleeve.

L. Alternate Slab-on-Grade Joint Load Transfer Systems: Install the alternate load transfer system in accordance with the manufacturer’s instructions such that the largest plane of the flat plate is parallel to the plane of the subgrade on which the slab is bearing.

M. Provide and place additional reinforcing steel at all sleeves and openings in beams, slabs and walls as specified on the drawings. Where sleeves or openings not shown on the drawings interrupt the reinforcement, consult with Engineer for instructions for placing

and splicing of bars. Provide required additional reinforcing steel at no additional cost to the Owner.

N. Epoxy-Coated Reinforcement: Use epoxy-coated steel tie wires to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963.

O. Galvanized Reinforcement: Use galvanized steel tie wires to fasten galvanized reinforcement. Repair cut and damaged zinc coatings with zinc repair material.

3.3 SPLICING REINFORCING STEEL

A. Provide splice as indicated on the drawings. Splice reinforcing bars only at locations shown on the structural drawings and approved shop drawings. Unauthorized or unscheduled splices not approved by the Engineer in writing will not be accepted.

B. All lap splices in reinforcing steel shall be contact lap splices unless detailed otherwise on the drawings.

C. Maintain proper cover between reinforcing bars at splices.

D. Lap unscheduled reinforcing bars not otherwise specified a minimum of 30 bar diameters at splices. Lap welded wire fabric a minimum of one full wire mesh plus two inches.

E. Reinforcing Steel Placement in Mat Foundations

1. Size, length, spacing, and location of all mat reinforcing steel is shown on the mat plans and details. See details on the drawings for required stagger pattern of top and bottom bar splices and for sequence of placing mat reinforcing steel layers.

2. The number of splices shall be minimized by using bar runs of 60'-0" as much as possible. Unless noted otherwise, continuous top reinforcing bars shall be spliced along column centerlines. Continuous bottom reinforcing bars shall be spliced mid-way between columns.

3. Provide Class B tension lap splices for all bars #11 and smaller. Stagger splices as shown in the typical details.

4. Avoid splices of #14 and #18 bars where possible. Where required, a mechanical tension splice as specified shall be provided. No more that 50% of such bars shall be spliced in any 5'-0" width of mat cross-section. Spliced bars shall be staggered with un-spliced bars.

F. Manufacturer of mechanical tension splice shall be present for first day's installation.

3.4 WELDING REINFORCING STEEL

A. Welding reinforcing steel is permitted only where specifically shown on the drawings. All welding shall conform to AWS D1.4. Only weldable reinforcing steel conforming to ASTM A 706 or deformed bar anchors conforming to ASTM A 496 shall be permitted. ASTM A 615 bars may not be welded for structural use.

B. Tack welding of reinforcement shall only be allowed for preassembled mats and cages.

3.5 SHRINKAGE AND TEMPERATURE REINFORCEMENT

A. Provide shrinkage and temperature reinforcement as indicated on the drawings at right angles to main top and bottom bars for all structural slabs unless detailed otherwise on the drawings.

3.6 PLACEMENT OF WELDED WIRE REINFORCEMENT

A. Wherever welded wire reinforcement is specified as reinforcement in pan-formed beams or slabs, it shall be continuous and properly lapped one full wire spacing plus 2" across the entire concrete surface and not interrupted by beam or girders.

3.7 REINFORCEMENT IN JOIST DISTRIBUTION RIBS

A. Provide reinforcement in ribs, minimum one - #5 continuous top and bottom unless indicated otherwise on the drawings.

3.8 REINFORCEMENT IN COMPOSITE METAL DECK SLAB

A. Composite metal deck slabs shall be reinforced as indicated on the drawings.

B. Extra Reinforcement Over Girders: Provide additional reinforcing steel over interior girders as shown on the drawings.

C. Placement of Slab Reinforcement: Provide bolsters, high chairs, and/or additional reinforcing as shown in details on the drawings to support the reinforcing with the clear cover shown on the drawings.

3.9 FIBER-REINFORCED CONCRETE IN TOPPING SLABS, SIDEWALKS, AND DRIVEWAYS

1. Provide fibers of the type and at the dosage rate shown on the drawings.

2. The fiber-reinforced concrete shall be produced in accordance with ASTM C 1116 and have a residual strength of 80 psi when tested in accordance with ASTM C 1399.

3.10 REINFORCEMENT AROUND OPENINGS IN COMPOSITE METAL DECK SLABS

A. For all openings in metal deck not framed with structural steel and greater than 10" in width in either direction, provide additional reinforcing steel as shown in details on the drawings.

3.11 REINFORCEMENT IN PAN-FORMED BEAM SLABS

A. Reinforcement: Provide reinforcing in pan-formed beam slabs as shown on the drawings.

B. Placement of Slab Reinforcement: Provide required bar supports and additional reinforcing as shown in details on the drawings to support slab reinforcing with the clear cover shown on the drawings.

3.12 REINFORCEMENT IN GRADE BEAMS

A. Provide reinforcing in grade beams as shown on the drawings.

B. Bar Support for Grade Beam Cages: Grade beam bottom steel shall be supported at 5'-0" maximum centers using beam bolsters that provide 3" bottom cover to the reinforcing steel. Beam bolsters used shall be designed and manufactured for support on soil.

3.13 REINFORCEMENT IN TOPPING SLABS

A. In addition to fiber reinforcing, provide welded smooth wire reinforcement minimum 6 x 6 W1.4 x W1.4 in all topping slabs unless specified otherwise on the drawings.

3.14 REINFORCEMENT IN HOUSEKEEPING PADS

A. In addition to fiber reinforcing, provide welded smooth wire reinforcement 6 x 6 W2.9 x W2.9 minimum in all housekeeping pads supporting mechanical equipment unless detailed otherwise on the drawings.

3.15 REINFORCEMENT IN SIDEWALKS

A. In addition to fiber reinforcing, provide welded smooth wire reinforcement minimum 6 x 6 W1.4 x W1.4 in all sidewalks unless detailed otherwise in the Contract Documents.

3.16 MECHANICAL AND PLUMBING REQUIREMENTS

A. Refer to Mechanical and Plumbing Drawings for concrete requiring reinforcing steel. Such reinforcement shall be furnished as part of the work of this section.

3.17 QUALITY ASSURANCE TESTING AND INSPECTION DURING CONSTRUCTION

A. See Testing Laboratory Services section of these Specifications for reinforcing inspection and testing requirements.

END OF SECTION 03 20 00

SECTION 03 30 00- CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-01 Specification sections, apply to work of this section.

B. Concrete paving and walks are specified in Division 32, Concrete Formwork – 03 10 00, Concrete Reinforcement – 03 20 00, Architectural Precast Concrete – 03 45 00, Structural Precast Concrete – 03 41 00, Post-Tensioned Concrete – 03 38 00, and special requirements for Tilt-up Concrete Construction – 03 47 13 are specified in other Division 03 sections.

1.2 DESCRIPTION OF WORK

A. Extent of concrete work is shown on drawings, including schedules, notes and details which show size and location of members and type of concrete to be poured. Furnish all labor, materials, services, equipment and hardware required in conjunction with or related to the forming, delivery and pouring of all cast-in-place concrete Work.

1.3 ENVIRONMENTAL OBJECTIVES

A. The Owner has established environmental goals and strategies for achieving them for this project based upon the LEED® Green Building Rating System for New Construction & Major Renovations Version 2009, as developed by the U.S. Green Building Council. Refer to Division 101 Section "Sustainable Design Requirements."

B. Manufacturer to supply documentation of level of compliance or non-compliance with the following requirements before consideration as an "acceptable manufacturer:"

1. The following are mandatory requirements for the overall project:

a. The material(s) in the product(s) supplied should have a recycled content such that the sum of the post-consumer recycled content plus one-half of the pre-consumer content constitutes at least [Percentage of required recycled materials]% of the total value of the material in the project.

b. [Percentage of close proximity material]% of the product(s) supplied is extracted, processed, and manufactured regionally within a radius of 500 miles of this Project.

1.4 QUALIFICATIONS

A. The concrete supplier shall have a minimum of five years experience in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment. The supplier must be certified according to the National Ready Mixed Concrete Association's Certification of Ready Mixed Concrete Production Facilities.

B. The concrete contractor shall have a minimum of five years experience with installation of concrete similar in material, design and extent to that indicated for this Project and whose work has resulted in construction with a record of successful –service performance.

C. Any testing laboratory retained by the Contractor or Subcontractor to run tests required by this specification but not performed by the Owner's testing laboratory shall meet the basic requirements of ASTM E 329.

1.5 QUALITY CONTROL

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

B. Codes and Standards: Comply with provisions of following codes, specifications and standards, except where more stringent requirements are shown or specified:

1. ACI 301 – "Specifications for Structural Concrete for Buildings".

2. ACI 117 – 'Specifications for Tolerances for Concrete Construction and Materials."

3. ACI 318 – "Building Code Requirements for Reinforced Concrete".

4. Concrete Reinforcing Steel Institute (CRSI), "Manual of Standard Practice".

5. Steel Construction Manual, 13th edition, American Institute of Steel Construction

C. Document Conflict and Precedence: In case of conflict among Contract Documents and Contract Specifications, request clarification from the Architect/Engineer through "Request for Information" (RFI) process before proceeding with the Work. In case of a conflict between and/or among the structural drawings and specifications, the strictest interpretation shall govern, unless specified otherwise in writing by the Architect/Engineer.

D. Inspection and Testing of the Work: Materials and installed work may require testing and retesting, as directed by the governing building code, the Architect/Engineer, or the Owner at any time during progress of work.

1. The Contractor shall provide forty-eight (48) hours notification to the Owner's Testing Laboratory of construction operations including the project schedule to allow the Testing Laboratory to schedule inspections. Failure to sufficiently notify may result in additional costs incurred by the Testing Laboratory that may be back-charged to the Contractor by the Owner.

2. The Contractor shall cooperate with laboratory personnel and provide access to the work.

3. The Contractor shall make arrangements with and for the Owner's Testing Laboratory for off-site inspection of material stockpiles, concrete delivery vehicles, concrete material storage facilities, and concrete-batching facilities.

4. If required, the Contractor shall furnish casual labor, equipment, and facilities as required for sampling and testing by the laboratory and otherwise facilitate the required inspections and tests.

5. Inspection or testing by the Owner does not relieve the Contractor of his responsibility to perform the Work in accordance with the Contract Documents. Tests not specifically indicated to be done at the Owner's expense, including retesting of rejected materials and installed work, shall be done at the

Contractor's expense. See Testing Laboratory section, 01 45 29, of the Specifications.

E. Acceptance Criteria for Concrete Strength: A strength test is defined as the average strength of two 6" x 12" cylinder breaks or three 4" x 8" cylinder breaks tested at the strength age indicated on the drawings for that class of concrete. The strength level of an individual class of concrete shall be considered satisfactory when both of the following requirements are met:

1. The average of all sets of three consecutive strength tests equal or exceed the required f'c.

2. No individual strength test falls below the required f'c by more than 0.1 f'c or 500 psi, whichever is greater.

F. Responsibility for Selection and use of concrete admixtures and chemical treatments: The Contractor shall be responsible for selecting admixtures and surface treatments that are compatible with the intended use of the concrete including all final surface treatments called for within this or other specifications or on the Contract Drawings. The Contractor is responsible for following the manufacturer's instructions for the use of their product including abiding by any limitations placed by the manufacturer on the use of any of its products.

G. Survey for Anchor Rods and Reinforcing Steel Dowels: The Contractor shall use a qualified and experienced filed engineer (construction surveyor), having a minimum of three years of experience as "lead" field engineer on projects of similar type, lay out the proper location of all embedded anchor rods, embedded connection plates for structural steel columns and beams, tension rods for structural precast, and correct location and elevation of concrete column dowels before they are encased in concrete.

H. Manufacturer Representative Presence:

1. Post-installed anchors: The manufacturer's representative for each post-installed anchor product (adhesive, expansion, undercut, screw, or insert anchor) shall be present during the first day's installation of the product to observe whether the anchors are installed according to manufacturer's instructions.

2. Fiber-reinforced concrete: The manufacturer's representative for each fiber type shall be present during the first pour in which the fiber is used to observe whether the dosage rate and placing and finishing method is in accordance with the specifications and the manufacturer's instruction.

1.6 PREINSTALLATION CONFERENCES

A. Mix Design Conference: At least 30 days prior to submittal of concrete design mixes, the Contractor shall hold a meeting or telephone conference to review the detailed requirements for preparing the concrete mix designs. Participants shall include representatives from the Contractor, UH Facilities Project Inspector, Owner's Testing Laboratory, Concrete Supplier, Architect, and Engineer.

B. Pre-Concrete Conference:

1. At least 7 days prior to beginning concrete work, the Contractor shall conduct a meeting to review the proposed mix designs and to discuss required methods and procedures to produce concrete construction of the required quality. Also

review requirements for submittals, status of coordinating work and availability of materials. Establish work progress schedule and procedures for materials inspection, testing and certifications. The contractor shall send a pre-concrete conference agenda to all attendees 7 days prior to the scheduled date of the conference.

2. The Contractor shall require responsible representatives of every party who is concerned with the concrete work to attend the conference, including but not limited to the following:

   Contractor's Superintendent
   Laboratory responsible for field quality control and batch plant quality control
   Concrete Subcontractor
   Ready-Mix Concrete Producer
   Concrete Pumping Contractor
   Fiber Reinforcement Representative
   Owner's and Architect's/Engineer's Representative

3. Minutes of the meeting shall be recorded, typed and printed by the Contractor and distributed by him to all parties concerned within 5 days of the meeting. One copy of the minutes shall be transmitted to the following for information purposes:

   Owner's Representative
   UH Facilities Project Inspector
   Architect
   Engineer-of-Record

4. The Engineer shall be present at the conference. The Contractor shall notify the Engineer at least 7 days prior to the scheduled date of the conference.

1.7 SUBMITTALS

A. Product Data: Submit manufacturer's product data with application and installation instructions for proprietary materials and items, including admixtures, patching compounds, epoxies, grouts, waterstops, joint systems, fiber reinforcement, curing compounds, dry-shake finish materials, hardeners, sealers mechanical splices, hooked anchorage systems, dowel bar substitute systems, dowel bar sleeves, joint fillers, and others as requested by Architect/Engineer.

B. Samples: Submit samples of materials specified if requested by Architect/Engineer, including names, sources and descriptions.

C. Mix Designs: Submit mix designs as specified herein.

D. Material and Mill Certificates: Provide material and mill certificates as specified herein and in the Testing Laboratory section of the Specifications. The Manufacturer and Contractor shall sign the material and mill certificates certifying that each material item complies with specified requirements. Provide certification from admixture manufacturers that chloride ion content complies with specified requirements.

E. Construction Joints: Submit drawing of proposed construction joint locations in concrete for slab on grade, mat foundations, structural floors, roofs and walls. Submit any additional or changed reinforcing that is required at construction joints that differs from that shown on the drawings.

F. Pour Sequence for Mat Foundation: Submit proposed pour sequence for mat foundations.

G. Industrial Slabs: Submit proposed pour sequence and procedure for protecting concrete during placement, finishing, and curing.

H. Minutes of preconstruction conference.

I. Surveys: Submit report certifying that all anchor rods and reinforcing dowels into columns above are in their proper location prior to placing of concrete.

J. LEED Submittals (Projects authorized for LEED certification only)

1. Recycled Content- Credit MR4.1/MR 4.2: Provide documentation indicating percentages of post-consumer and pre-consumer recycled content by weight per unit of product or assembly containing the product. Indicate the percentage of the dollar value of the recycled content compared to the total dollar value of the product or assembly containing the product.

2. Material Proximity- Credit MR 5.1/MR 5.2: Where the distances to the project site is 500 miles or less, indicate location and distance to project site of extraction, harvesting, recovery and manufacturing of all materials. Indicate the dollar value of the material cost of the product containing local/regional materials. Where product components are sourced or manufactured in separate locations, provide location and percentage by weight of each component per unit of product.

1.8 PROVISION FOR OTHER WORK

A. Provide for installation of inserts, hangers, metal ties, anchors, bolts, angle guards, dowels, thimbles, slots, nailing strips, blocking, grounds and other fastening devices required for attachment of work. Properly locate in cooperation with other trades and secure in position before concrete is poured. Do not install sleeves or blockouts in any concrete slabs, beams or columns except where shown on the drawings or upon written approval of the Architect/Engineer.

B. Protect adjacent finish materials against damage and spatter during concrete placement.

C. To maintain location accuracy, the General Contractor’s field engineer shall furnish building control lines and elevation bench marks for the use of all trades.

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

A. Refer to the drawings for classes and strengths of concrete required.

B. Hydraulic Cement:

1. Use ASTM C 150, Type I or Type III, or ASTM C 1157, Type GU or HE unless otherwise specified. Do not use Type III cement in slabs on grade unless approved in advance by the Engineer.

2. Concrete exposed to sulfates in soil or water

a. Exposure class S1: For areas designated on the drawings as exposure class S1, use ASTM C 150, Type II or ASTM C 1157, Type MS.
b. Exposure class S2: For areas designated on the drawings as exposure class S2, use ASTM C 150, Type V or ASTM C 1157, Type HS.
c. Alternate cement types for exposure classes and S2: ASTM C 150, Type I or III cement may be used for concrete exposed to exposure S1 or S2 if the tricalcium aluminate (C3A) content is less than 8 percent for S1 exposure or 5 percent for S2 exposure ASTM C 150, Type I or III cement may be used for exposure to seawater if the tricalcium aluminate content does not exceed 10 percent and the w/cm ratio of the concrete mix does not exceed 0.40.
d. Exposure class S3: For areas designated on the drawings as exposure class S3, use ASTM C 150, Type V plus pozzolan or slag or ASTM C 1157, Type HS plus pozzolan or slag or ASTM C 595, Type IP (HS) or Type IS (HS). The amount of pozzolan or slag added or in a blended mix shall be such that has been determined by service record to improve sulfate resistance when used with Type V cement or the amount that when tested according to ASTM C 1012 meets the criteria of table 4.5.1 in ACI 318-08.

3. Use one brand of cement, for each class of concrete, throughout the project, unless approved otherwise by the Architect/Engineer and the Owner's Testing Laboratory. Submit mill certificates certifying conformance to this specification for each brand and type of cement. Documentation of design mix strength history must match the cement brand used.

4. Testing of cement in lieu of mill certificate submittal will be required if:

a. The cement has been in storage at the mixing site for over 30 days
b. It is suspected by the Owner, Architect, Engineer or Owner's Testing Laboratory that the cement has been damaged in storage or in transit or is in any way defective.

C. Low-alkali cement: Cement that has the additional requirement that equivalent alkalis ($Na_2O + 0.658K_2O$) do not exceed 0.60% according to ASTM C 150-00, Table 2.

D. Expansive Cement: ASTM C 845, Type K.

E. Fly Ash: ASTM C 618, Class C or F.

F. Silica Fume: ASTM C 1240, Amorphous Silica.

G. Slag Cement: ASTM C 989, Grade 100 or 120 or ASTM C 595, Type IS or Type S.

H. Normal weight Aggregates: ASTM C 33, and as herein specified. Submit material certificates from aggregate supplier or test results from an independent testing Labratory certifying conformance to this specification for each source of aggregate.

1. For concrete identified on the drawings as exposed to exposure classes C1 and C2, submit certification that aggregate does not contain any deleterious materials that react with alkalis in the concrete mix to cause excessive expansion of the concrete for concrete that is exposed to wetting, has extended exposure to humid atmosphere, or is in contact with moist ground unless low-alkali cement is used.

I. Lightweight Aggregates: ASTM C 330. Submit material certificates from aggregate supplier or test results from an independent testing Labratory certifying conformance to this specification for each source of aggregate.

J. Water: Comply with the requirements of ASTM C 1602

K. Cementitious materials, aggregate, and water must be extracted or recovered as well as manufactured within 500 miles of the project site.

L. Air-Entraining Admixture: ASTM C 260.

Subject to compliance with requirements, provide one of the following products and manufacturers:

"Darex" or "Daravair" series; W. R. Grace & Co.
“MB-VR”, "MB-AE90" or "Micro-Air"; BASF Admixtures, Inc
"Sika AER"; Sika Corporation
"Air Mix" or "AEA-92"; the Euclid Chemical Company
“Eucon Air 30” or “Eucon Air 40”, the Euclid Chemical Company.

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

M. Water-Reducing Admixture: ASTM C 494, Type A. See maximum permissible chloride ion content in concrete specified below.

Subject to compliance with requirements, provide one of the following products and manufacturers:

"Pozzolith" series; BASF Construction Chemicals
"Plastocrete 161"; Sika Chemical Corp.
"Eucon WR-75 or WR-91"; the Euclid Chemical Company.
"WRDA "; series W.R. Grace & Co.
“Eucon NW” or “Eucon LW”, the Euclid Chemical Company

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

N. Mid-Range Water-Reducing Admixture: ASTM C 494, Type A and Type F. See maximum permissible chloride ion content in concrete specified below.

Subject to compliance with requirements, provide one of the following products and manufacturers:

“Polyheed” series, BASF Construction Chemicals
“Eucon MR”, the Euclid Chemical Company
“Sikament HP”, Sika Chemical Corp.
“Daracem” or “Mira” series, W.R. Grace & Co.
“Eucon X15” or “Eucon X20”, the Euclid Chemical Company

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

O. High-Range Water-Reducing Admixture (superplasticizer): ASTM C 494, Type F or Type G. See maximum permissible chloride ion content in concrete specified below.

Subject to compliance with requirements, provide one of the following products and manufacturers:

"ADVA" or "Daracem" Series; W.R. Grace & Co.
"Rheobuild 1000" or "Glenium" series; BASF Construction Chemicals
"Sikament"; Sika Chemical Corp.
"Eucon 37/1037" or "Plastol" series; the Euclid Chemical Company
"Euconl SP" or "Eucon RD", the Euclid Chemical Company

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

P. Water-Reducing, Accelerator Admixture (Non-Corrosive, Non-Chloride): ASTM C 494, Type C or E. See maximum permissible chloride ion content in concrete specified below.

Subject to compliance with requirements, provide one of the following products and manufacturers:

"Polarset";"Gilco", "Lubricon NCA" or "DCI", W.R. Grace & Co.
"Pozzutec 20+"; BASF Construction Chemicals
"Accelguard 80/90"; "NCA", or "AcN", the Euclid Chemical Company
"Plastocrete 161FL", Sika Chemical Co.
"Eucon AcN", the Euclid Chemical Company

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

Q. Water-Reducing, Retarding Admixture: ASTM C 494, Type D. See maximum permissible chloride ion content in concrete specified below.

Subject to compliance with requirements, provide one of the following products and manufacturers:

"Daratard" series, W.R. Grace & Co.
"Pozzolith" series or "DELVO" series; BASF Construction Chemicals
"Plastiment"; Sika Chemical Co.
"Eucon Retarder", Series, the Euclid Chemical Company

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

R. Viscosity Modifying Admixture: Used to enhance plastic concrete properties such as workability, pumpability, and stability for "self-consolidating concrete".

"Rheomac VMA" series, BASF Construction Chemicals
"Eucon SL" or "Visctrol", the Euclid Chemical Company
"VisoCrete" series, Sika Chemical Co.
"VMAR" series, W.R. Grace & Co.

S. Shrinkage Reducing Admixture: An admixture that reduces drying shrinkage by reducing the capillary tension of pore water.

Subject to compliance with requirements, provide one of the following products and manufacturers:

For Air-Entrained Concrete:

"Eclipse Plus"'; Grace Construction Products
"Eucon SRA"; the Euclid Chemical Company

For Non Air-Entrained Concrete

"Eclipse Floor", Grace Construction Products
"Tetraguard AS20", BASF Construction Chemicals

T. Corrosion Inhibitor: 30% calcium nitrite

Products: Subject to compliance with requirements, provide the following at dosage rates per Engineer of Record from manufacturer's recommendation based on design life, application, clear cover and other products in concrete mix:

"Eucon CIA" or "Eucon BCN", the Euclid Chemical Company
"DCI" or "DCI-S", W.R. Grace & Co.
"Rheocrete CNI", BASF Construction Chemicals
"Sika CNI", Sika Chemical Co.

U. Corrosion Inhibitor: Amine-Ester type

Products: Subject to compliance with requirements, provide the following at dosage rates per manufacturer's recommendation:

"Rheocrete 222+", BASF Construction Chemicals

V. Crystalline-forming Waterproofing Admixture: An powder admixture capable of producing concrete that is water tight under hydrostatic pressure up to 7 atmospheres when tested in accordance with Corps of Engineers test CRD-C48 and capable of sealing cracks up to 0.4mm.

Products: Subject to compliance with requirements, provide the following at dosage rates per manufacturer's recommendation:

"Penetron Admix", ICS/Penetron International/Ltd.
"Krystol Internal Membrane", Kryton International, Inc.
"Xypex C series", Xypex Chemical Corporation
"Rheomac 300D", BASF Construction Chemicals

W. Calcium Chloride and Chloride Ion Content: Calcium chloride or admixtures containing more than 0.5% chloride ions by weight of the admixture are not permitted. For concrete exposed to sulfate exposure class S2 or S3 as noted on the drawings, admixtures must be completely free of chloride ions.

X. Certification: Written conformance to all the above mentioned requirements and the chloride ion content of the admixture as tested by an accredited laboratory will be required from the admixture manufacturer at the time of mix design review by the Engineer.

2.2 RELATED MATERIALS

A. Waterstops: Provide waterstops at all construction joints and other joints in all foundation walls below grade and where shown on the drawings. Size to suit joints. Provide flat, dumbbell type or center bulb type where shown on drawings.

1. ADCOR ES waterstops: W.R. Grace & Co.

2. Polyvinyl chloride (PVC) waterstops: Corps of Engineers CRD-C 572.

3. Preformed Plastic Waterstops: Federal Specifications SS-S-210A "Sealing Compound for Expansion Joints".

   Manufacturers: Synko-Flex Products, Inc.

4. Bentonite Waterstop RX manufactured by American Volclay Products.

B. Vapor Retarder: Provide vapor retarder cover chosen from products specified below over prepared base material where indicated.

1. Plastic Vapor Retarder Provide a flexible preformed sheet membrane conforming to ASTM E 1745 with the following properties.

   a. Class A material
   b. Minimum of 15 mils thick
   c. Maximum water vapor permeance rating of 0.01 Perms after mandatory conditioning as tested by ASTM E 96
   d. Acceptable products include the following:

      "Stego Wrap Vapor Barrier (15 mil)", Stego Industries, LLC
      “Ecoshield-E” (15 mil), Epro
      “Monarflex Reflex Super, Monarflex

2. Tape for Plastic Vapor Retarders: High-density polyethylene tape with pressure sensitive adhesive having a minimum width of 4 inches having a maximum water vapor transmission rate of .3 perms.

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

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

1. Waterproof paper.

2. Polyethylene film.

3. Polyethylene-coated burlap.

4. Polyethylene-coated natural cellulose fabric such as “Aquacure” by Greenstreak Group, Inc.

5. Cover for Industrial Slab: Provide a low permeance moisture-retaining cover that allows a moisture loss of no more than 1 lb/sq. yd. in 72 h when tested in accordance with ATSM C 156 for industrial slabs. The material shall be non-staining with a tensile strength meeting ASTM D 882 and a minimum retention capacity of 6.5 g.

E. Slip-resistive Emery Aggregate or Aluminum Granule Finish: Provide fused aluminum-oxide granules, or crushed emery, as abrasive aggregate for slip-resistive finish. The emery aggregate shall contain not less than 50% aluminum oxide and not less than 20%

ferric oxide. The aluminum aggregate material shall contain not less than 95% fused aluminum-oxide granules. Use material that is factory-graded, packaged, rust-proof and non-glazing, and is unaffected by freezing, moisture and cleaning materials.

Subject to compliance with requirements, provide one of the following:

"Emery Tuff Non-Slip", Dayton-Superior
"Grip-It" or “Grip-It AO”, L&M Construction Chemicals, Inc
“Frictex NS”, Sonneborn-ChemRex

F. Colored, Mineral Aggregate, Dry Shake Surface Hardener: Packaged, dry, combination of materials, consisting of portland cement, graded quartz aggregate, coloring pigments (if required) and plasticizing admixtures. Use coloring pigments that are finely ground, non-fading mineral oxides, interground with cement. Color, as selected by Architect, unless otherwise indicated.

Products: Subject to compliance with requirements, provide one of the following:

"Surflex"; the Euclid Chemical Company
"Quartz Plate"; L & M Const. Chemical Co.
“Lithochrome”, LM Scofield Construction Chemical Co.
"Mastercron"; BASF Building Systems
"Quartz-Tuff“, Dayton Superior
“US Spec Dense Top”, US Mix Co.

Submit manufacturer's certification that product conforms to the requirements specified.

G. Metallic Aggregate Hardener Finish: Packaged dry, combination of materials consisting of Portland Cement, specially processed and graded iron aggregate, coloring pigments (if required) and plasticizing admixtures. The hardener shall be formulated, processed and packaged under stringent quality control. Use coloring pigments that are finely ground, non-fading mineral oxides inter-ground with cement. Color as selected by Architect unless otherwise indicated.

"Euco-Plate HD"; the Euclid Chemical Company
"Masterplate 200"; BASF Building Systems
"Ferro Tuff," Dayton-Superior

H. Non-Oxidizing Metallic Floor Hardener: Packaged dry, combination of materials consisting of portland cement, non-rusting aggregate and plasticizing admixtures.

"Diamond Plate," the Euclid Chemical Company
"Lumiplate," BASF Building Systems

I. Liquid Membrane-Forming Curing and Curing and Sealing Compounds:

1. Water-Based Dissipating Resin Type Curing Compound: Curing Compound shall be a dissipating resin type, which chemically breaks down after approximately 4 weeks. Membrane forming compound shall meet ASTM C 309, Types 1 or 1D, Class B with VOC content less than 350 g/L.

Products: Subject to compliance with requirements, provide one of the following:

"Kurez DR Vox”, the Euclid Chemical Company
"L&M Cure R", L&M Construction Chemicals
“Hydro Cure 309”, Unitex

"Sealtight 1100-Clear", W. R. Meadows
"US Spec Maxcure Resin Clear", US Mix Co.

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with any covering or surface treatments to be applied. Submit any instructions that must be followed prior to any subsequent surface treatments and floor coverings.

2. High Solids, Water-Based Acrylic Curing and Sealing Compound with Moderate Yellowing Characteristics: Water-Based membrane-forming curing and sealing compound conforming to ASTM C 1315, Type 1, Class B, classified as low odor with a VOC content less than 350 g/L. Product shall provide a maximum moisture loss of 0.030 Kg/m^2 in 72 hours when applied at a coverage rate of 300 sf/gallon. Do not apply to surfaces that are to receive subsequent cementitious toppings, sealers, hardeners, ceramic tile, resilient flooring, vinyl-backed carpet, wood, or terrazzo, epoxy overlays or adhesives, or other coating or finishing products.

   Products: Subject to compliance with above requirements, provide one of the following products or equivalent products:

   "Safe Cure and Seal (J-19)"; Dayton Superior Corp.
   "Super Aqua-Cure VOX"; the Euclid Chemical Company
   "Dress & Seal, 30 WB"; L & M Construction Chemicals, Inc.
   "Masterkure 200W"; BASF Building Systems
   "Hydro 18", Unitex

   Submit manufacturer's certification that product conforms to the requirements specified and is compatible with any covering or surface treatments to be applied. Submit any instructions that must be followed prior to any subsequent surface treatments.

3. High Solids, Water-Based, Non-Yellowing Curing and Sealing Compound: Water based membrane-forming curing and sealing compound, acrylic type, complying with ASTM C 1315, Type 1, Class A classified as low odor with a VOC content less than 350 g/L. Do not apply to surfaces that are to receive subsequent cementitious toppings, sealers, hardeners, ceramic tile resilient flooring, vinyl-backed carpet, wood, terrazzo, epoxy overlays or adhesives, or other coating or finishing products.

   Products: Subject to compliance with requirements, provide one of the following:

   "Super Diamond Clear Vox", the Euclid Chemical Company
   "Lumiseal 30 WB", L&M Construction Chemicals
   "Kure 1315", BASF Building Systems
   "Hydro Seal 30", Unitex
   "Vocomp 30", W. R. Meadows
   "US Spec Radiance UV-25", US Mix Co.

   Submit manufacturer's certification that product conforms to the requirements specified and is compatible with any covering or surface treatments to be applied. Submit any instructions that must be followed prior to any subsequent surface treatments.

J. Evaporation Control: Monomolecular film forming compound applied to exposed concrete slab surfaces for temporary protection from rapid moisture loss in hot weather conditions.

Products: Subject to compliance with requirements, provide one of the following:

"Eucobar"; the Euclid Chemical Company
"E-Con"; L & M Construction Chemical, Inc.
"Confilm"; BASF Building Systems
"Sure Film (J-74)", Dayton Superior
"SikaFilm", Sika Chemical Co.
“Pro-Film”, Unitex
“Sealtight Evapre”, W. R. Meadows
“US Spec Monofilm ER”, US Mix Co.

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all coverings and surface treatments to be applied. Submit any instructions that must be followed prior to any subsequent surface treatments.

K. Chemical Curing/Floor Hardener Compound: Sodium silicate based compound which reacts with concrete constituents to harden the surface, resulting in a surface having a maximum abrasion coefficient of 0.25 cm3/cm2 when tested in accordance with ASTM C 418.

Products: Subject to compliance with requirements, provide one of the following:

"Eucosil," the Euclid Chemical Company
"Sonosil," BASF Building Systems
"Day-Chem S.1-Cure (J-13), Dayton Superior
"Chem Hard;" L & M Construction Co.
“Uni Cure HD”, Unitex
“Med-Cure”, W. R. Meadows
“US Spec Permasil”, US Mix Co.

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all coverings and surface treatments to be applied. Submit any instructions that must be followed prior to any subsequent surface treatments.

L. Chemical Hardener: Colorless aqueous solution containing a blend of magnesium fluosilicate and zinc fluosilicate combined with a wetting agent, containing not less than 2 lbs. of fluosilicates per gal.

Products: Subject to compliance with requirements, provide one of the following:

"Surfhard"; the Euclid Chemical Company
"Lapidolith"; BASF Building Systems
"Day-Chem Hardener (J-15)," Dayton Superior
“Fluohard”, L & M Construction Chemical, Inc.
“Penalith”, W. R. Meadows

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all coverings or surface treatments to be received. Submit any instructions that must be followed prior to any subsequent surface treatments.

M. Liquid sealer/densifier: High performance, deeply penetrating concrete densifier that is an odorless, colorless, VOC-compliant, non-yellowing siliconate-based solution containing a minimum solids content of 20%, 50% of which is siliconate.

"Euco Diamond Hard", the Euclid Chemical Company
"Seal Hard", L & M Construction Chemical, Inc.
"Luqui-Hard", W.R. Meadows

N. Water and Chloride Ion Repelling Penetrating Sealer: Clear, solvent based silane or siloxane penetrating sealer which reacts chemically with the concrete surface to function as a Chloride Ion screen with a minimum 90% factor when tested in accordance with NCHRP #244, Series II, 100% solids, and applied in accordance with the manufacturer's recommendation.

Products: Subject to compliance with requirements, provide one of the following:

a. "Hydrozo 100", BASF Building Systems.
b. "Iso-flex 618-100 CRS", Lymtal International, Inc.
c. "Protectosil Chem-Trete BSM-400", Evonik Industries

O. Water and Chloride Ion Repelling Penetrating Sealer: Clear, solvent free, silane penetrating sealer which reacts chemically with the concrete surface to function as a Chloride Ion screen with a minimum 83% factor when tested in accordance with NCHRP #244, Series II and applied in accordance with the manufacturer's recommendation.

Products: Subject to compliance with requirements, provide one of the following:

1. 40% solids:

a. "Enviroseal 40" –BASF Building Systems
b. "Iso-flex 618-40 WB", Lymtal International, Inc.

2. 100% solids:

a. "Protectosil BH-N", Evonik Industries

P. Bonding Compound: Polyvinyl acetate or acrylic base, for use in cosmetic and/or nonstructural repairs.

Products: Subject to compliance with requirements, provide one of the following:

1. Acrylic or Styrene Butadiene:

"Day-Chem Ad Bond (J-40)"; Dayton Superior
"SBR Latex"; the Euclid Chemical Company
"Daraweld C"; W. R. Grace
"Acrylic Additive" BASF Building Systems
"SikaLatex", Sika Chemical Co.
"Intralok", W. R. Meadows
"US Spec Acrylcoat", US Mix Co.
"Akkro 7-T", the Euclid Chemical Company

2. Polyvinyl Acetate (Interior Use Only)

"Tammseld"; the Euclid Chemical Company

"Everweld"; L & M Construction Chemicals, Inc.
"Superior Concrete Bonder (J-41)," Dayton Superior
“US Spec Bondcoat”, US Mix Co.

Q. Epoxy Products: Two component material suitable for use on dry or damp surface, complying with ASTM C 881.

1. Products for Crack Repair:

"Sikadur 35 Hi Mod LV"; Sika Chemical Company – injection type
"Sikadur 52", Sika Chemical Company – injection type
"Sikadur 55 SLV", Sika Chemical Company – gravity feed
"Eucopoxy Injection Resin," the Euclid Chemical Company
"Sure-Inject (J-56)," Dayton Superior
“Epofil SLV”, BASF Building Systems
“ETI-LV” or “ETI-GV”, Simpson Strong-Tie Co., Inc. – injection type
“Pro-Poxy 100 LV” or “Pro-Poxy 50”, Unitex
“Crackbond”, U.S. Anchor Corp.
“Rezi-Weld LV”, W. R. Meadows
“US Spec Maxibond” US Mix Co. – injection or gravity feed
“US Spec Eposeal LVS”, US Mix Co. – gravity feed
“Duralcrete LV”, the Euclid Chemical Company

2. Products for Epoxy Mortar Patches:

"Sikadur Lo-Mod LV"; Sika Chemical Corporation
""Duracrete”, the Euclid Chemical Company
"Sure Grip Epoxy Grout (J-54)," Dayton-Superior
“Epofil”, BASF Building Systems
“Pro-Poxy 2500”, Unitex
“Rezi-Weld 1000”, W. R. Meadows
“US Spec EPM 3000”, US Mix Co.
“Duralcrete LV”, the Euclid Chemical Company

3. Products for Epoxying steel plates to concrete: conform to ASTM C 881-90, Type IV, Grade 3, Class A, B, & C except gel times.

"Sikadur 31 Hi-Mod Gel"; Sika Corporation
"Sure Anchor I (J-S1)," Dayton Superior
"Epo Gel" or "Rapid Gel", BASF Building Systems
“Pro-Poxy 300”, Unitex
“US Spec Gelbond NS” US Mix Co.
“Duralcrete Gel”, the Euclid Chemical Company

4. Products for Adhesive Anchors or Reinforcing Steel in Normal weight Concrete: Product that conforms to ASTM C 881-02, Type IV, Grade 3, Class A, B, & C except gel times, and that is dispensed from a two-component cartridge system through a mixing nozzle that thoroughly mixes the two components as it is injected into the hole.

a. ICC Approval: Only anchors evaluated by the ICC Evaluation Service, Inc. (ICC-ES) with a published, currently valid, Evaluation Report showing it as having passed Acceptance Criteria 308 shall be approved for use.
b. Consult with the manufacturer for the minimum temperature of the concrete substrate allowed.

c. All anchors installed upwardly inclined require continuous inspection unless an exception to the continuous special inspection for upwardly inclined installation is noted on the drawings.

d. Normal weight Concrete:

"HIT-RE 500-SD", Hilti Fastening Systems (periodic inspection unless anchors are installed upwardly inclined)
"SET-XP" Adhesive", Simpson Strong-tie (periodic inspection unless higher factors are used in design requiring continuous inspection as noted on the drawings or anchors are installed upwardly inclined)
"PE 1000+", Powers Fasteners, Inc. (periodic inspection unless anchors are installed upwardly inclined)
HIT-HY 150 MAX-SD", Hilti Fastening Systems (periodic inspection unless anchors are installed upwardly inclined)

e. Lightweight Concrete:

No approved products

f. These products may not be used in concrete cast over corrugated deck.

g. Install only anchors identified on the drawings by manufacturer and product. Substitutions using products approved by this Specification may be permitted provided complete design calculations, as required by and in accordance with the proposed product's current and valid ICC Evaluation Service Report (ESR) and ACI 318 Appendix D, are signed and sealed by a professional engineer licensed in the state where the project is located and furnished to the Engineer for review and approval prior to commencement of work. The contractor shall request design criteria for all conditions where a product substitution is considered. Failure to obtain approval for an anchor substitution may result in the request by the Engineer to remove installed anchors and replace with the product specified on the drawings at the Contractor's expense.

R. Self-Leveling Mortars, Underlayment Compound: Free flowing, self-leveling, pumpable cementitious base compound. Follow manufacturer's instruction regarding the use of a bonding agent.

Products: Unless specified otherwise, provide one of the following:

"Sonoflow," BASF Building Systems
"Sikatop 111"; Sika Chemical Co.
"Flo-Top" or "Super Flo-Top"; the Euclid Chemical Company
"Levelayer I," Dayton Superior
"US Spec Self-leveling Underlayment" US Mix Co.
"Level Magic", the Euclid Chemical Company

S. Polymer Patching Mortar: Polymer and microsilica modified cementitious based compounds.

Products:

<u>Horizontal Application</u>

"Thin Top Supreme, Concrete Top Supreme," the Euclid Chemical Company

"Sikatop 121 or 122," Sika Chemical
"Emaco R310 CI," BASF Building Systems
“Sonopatch 100 or 200”, BASF Building Systems
“US Spec H2 or NuTop” US Mix Co.
“Speed Crete PM”, the Euclid Chemical Company

Upwardly Inclined Application

"Verticoat/Verticoat Supreme," the Euclid Chemical Company
"Sikatop 123," Sika Chemical
"Emaco R350 CI," BASF Building Systems
“Sonopatch 200”, BASF Building Systems
“US Spec V/O Patch”, US Mix Co.
“Speed Crete PM”, the Euclid Chemical Company

T. High Strength Flowing Repair Mortar: For forming and pouring structural members, or large horizontal repairs, provide flowable one-part, high strength microsilica polymer modified repair mortar with 3/8" aggregate. The product shall achieve 9000 psi @ 28-days at a 9-inch slump.

Products:

“Road Patch”, BASF Building Systems
“US Spec STR Mortar”, US Mix Co.
“Eucocrete”, the Euclid Chemical Company
“Form and Pour”, the Euclid Chemical Company

U. Anti-Corrosive Epoxy/Cementitious Adhesive: Water-based epoxy/cementitious compound for adhesion and corrosion protection or reinforcing members (20 hour maximum open time).

Products:

"Duralprep A.C", the Euclid Chemical Company
"Armatec 110," Sika Chemical Co.
“Sonoprep Plus”, BASF Building Systems

V. Expansion and Undercut Anchors in Concrete:

1. ICC Approval: Only anchors evaluated by the ICC Evaluation Service, Inc. (ICC-ES) with a published, currently valid, Evaluation Report showing it as having passed Acceptance Criteria 193 and approval for use in cracked concrete and resisting wind and seismic loads shall be approved for use.

2. Type: All expansion and undercut anchors in concrete shall be only wedge type expansion, sleeve-type expansion, or undercut type anchors.

3. Interior Use: All anchors, 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-325C, Type II, Class 3.

4. Exterior or Exposed Use: All anchors, nuts and washers for use in exposed or potentially wet environments, or for attachment of exterior cladding materials shall be galvanized or stainless steel. Galvanized anchors, nuts and washers shall conform to ASTM A 153. Stainless steel anchors shall be manufactured

from 300 series stainless steel and nuts and washers from 300 series or Type 18-8 stainless steel.

5. Nuts and Washers: Nuts and washers shall be furnished from the manufacturer and used with the anchors.

6. Acceptable Products and Manufacturers – Normal and Lightweight Concrete:

"Kwik Bolt TZ", Hilti Fastening Systems (periodic inspection)
"HDA Undercut Anchor" Hilti Fastening Systems (continuous inspection)
"HSL-3 Heavy Duty Sleeve Anchor", Hilti Fastening Systems (continuous inspection)
"Strong-Bolt Wedge Anchor", Simpson Strong-Tie, Co., Inc. (continuous inspection)
"Red Head Trubolt + Wedge Anchor", ITW Red Head (periodic inspection)
"DUC Undercut Anchor", USP Structural Connectors (continuous inspection)
"Power Stud + SD1", Powers Fasteners, Inc (periodic inspection)
"Power Stud + SD2", Powers Fasteners, Inc (periodic inspection)
"SRS TZ Carbon Steel Anchor", MKT Metall-Kunststoff-Technik (continuous inspection)

7. Acceptable Products and Manufacturers – Normal and Light Weight Concrete on Corrugated Deck:

"Kwik Bolt TZ", Hilti Fastening System (periodic inspection)
Strong-Bolt Wedge-Anchor", Simpson Strong-Tie, Co, Inc. (continuous inspection)
Power Stud + SD2", Powers Fasteners, Inc. (periodic inspection)

8. Install only anchors identified on the drawings by manufacturer and product. Substitutions using products approved by this Specification may be permitted provided complete design calculations, as required by and in accordance with the proposed product's current and valid ICC Evaluation Service Report (ESR) and ACI 318 Appendix D, are signed and sealed by a professional engineer licensed in the state where the project is located and furnished to the Engineer for review and approval prior to commencement of work. The contractor shall request design criteria for all conditions where a product substitution is considered. Failure to obtain approval for an anchor substitution may result in the request by the Engineer to remove installed anchors and replace with the product specified on the drawings at the Contractor's expense.

W. Screw and Insert Anchors in Concrete

1. Approvals: Only anchors evaluated by the ICC Evaluation Service, Inc. (ICC-ES) with a published, currently valid, Evaluation Report showing it as having passed Acceptance Criteria 193 and approved for use in cracked concrete and resisting wind and seismic loads shall be approved for use.

2. Interior Use: All screw anchors 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-325C, Type II, Class 3.

3. Exterior or Exposed Use: All screw anchors for use in exposed or potentially wet environments, or for attachment of exterior cladding materials shall be galvanized

or stainless steel. Galvanized anchors shall conform to ASTM A 153. Stainless steel anchors shall be manufactured from 300 series stainless steel.

4. Acceptable Products and Manufacturers – All Conditions:

"Titen HD", Simpson Strong-Tie Co., Inc (continuous inspection)
"Snake+Anchor" Powers Fasteners, Inc. (periodic inspection)
"Wedge-Bolt+", Powers Fasteners, Inc. (greater than ¼ in. diameter) (periodic inspection)

5. Install only anchors identified on the drawings by manufacturer and product. Substitutions using products approved by this Specification may be permitted provided complete design calculations, as required by and in accordance with the proposed product's current and valid ICC Evaluation Service Report (ESR) and ACI 318 Appendix D, are signed and sealed by a professional engineer licensed in the state of Texas and furnished to the Engineer for review and approval prior to commencement of work. The contractor shall request design criteria for all conditions where a product substitution is considered. Failure to obtain approval for an anchor substitution may result in the request by the Engineer to remove installed anchors and replace with the product specified on the drawings at the Contractor's expense.

X. Threaded Rods Chemically Anchored in Concrete

1. Type: Threaded rods installed in holes using a chemical anchoring process shall have a 45º chiseled end on one end.

2. Interior and Exterior Application: Meet the requirements of ASTM A 153 galvanized steel, or F 593, Group 1 or 2, condition CW stainless steel.

Y. Anchor Rods:

1. All anchor rods shall conform to the ASTM designation and shall be of the yield strength as specified below as appropriate for the types and at the locations as specified on the drawings:

   a. ASTM F 1554, Grade 36 (1/4 inch to 4 inches in diameter).
   b. ASTM F 1554, Grade 55 (1/4 inch to 4 inches in diameter). (Also comply with Supplementary Requirement S1 of ASTM F 1554)
   c. ASTM F 1554, Grade 105 (1/4 inch to 3 inches in diameter.
   d. ASTM A 588 (corrosion resistant).
   e. ASTM A 354 Grade BD, 130 ksi (to 2 ½ inches in diameter).
   f. ASTM A 354 Grade BD, 115 ksi (greater than 2 ½ inches to 4 inches in diameter).
   g. ASTM A 354 Grade BC, 109 ksi (to 2 ½ inches in diameter).
   h. ASTM A 354 Grade BC, 99 ksi (greater than 2 ½ inches to 4 inches in diameter).

2. Anchor rods used with ASTM A 588 base plates shall be threaded round stock conforming to ASTM A 588, grade 50.

3. Anchor rods used with ASTM A 588 base plates shall be threaded round stock conforming to ASTM A 588, grade 50.

4. Anchor rods used with galvanized base plates shall be galvanized.

5. Nuts: All nuts with anchor rods shall be heavy hex head conforming to ASTM A 563.

6. Washers: Unless noted otherwise on the drawings, washer size and thickness for all anchor rods shall conform to Table 14-2 of AISC “Steel Construction Manual” with holes 1/16” greater than the anchor rod diameter. Washers shall conform to ASTM A 36 steel.

Z. Non-Shrink Grout:

1. Type: Grout for base plates, bearing plates and grouting under precast or tilt-up wall panels shall be a non-metallic, shrinkage resistant, premixed, non-corrosive, non-staining product containing Portland cement, silica sands, shrinkage compensating agents and fluidity improving compounds.

2. Specifications: Non-shrink grout shall conform to ASTM C 1107.

3. Compressive Strength: Provide the minimum strength as shown below as determined by grout cube tests at 28 days:

   a. 6,000 PSI for supporting concrete 3000 psi and less.
   b. 8,000 PSI for supporting concrete greater than 3000 psi and less than or equal to 4000 psi.
   c. Unless noted otherwise on the drawings, grout strength on supporting concrete greater than 4000 psi shall be 8000 psi.

4. Products: Acceptable non-shrink grouts are listed below:

   "Crystex"; L & M Construction Chemicals, Inc.
   "Masterflow 713 Plus"; BASF Building Systems
   "Set Grout," BASF Building Systems.
   "Five Star Grout"; U. S. Grout Corp.
   "Sonogrout 10K"; BASF Building Systems
   "NS Grout"; the Euclid Chemical Company
   "Sure-Grip High Performance Grout"; Dayton Superior Corp.
   "CG 200 PC", Hilti, Inc.
   “CG-86 Grout”, W. R. Meadows
   “US Spec GP Grout”, US Mix Co.

5. High Flow, Non-Metallic Grout: Use high-flow grout where high fluidity and/or increased placing time is required and for base plates that are larger than 10 square feet. The factory pre-mixed grout shall conform to ASTM C 1107, "Standard Specification for Packages Dry, Hydraulic-Cement Grout (Non-Shrink)." In addition, the grout manufacturer shall furnish test data from an independent laboratory indicating that the grout when placed at a fluid consistency shall achieve 95% bearing under a 18" x 36" base plate. Provide one of the following:

   "Hi-Flow Grout," the Euclid Chemical Company
   "Masterflow 928," BASF Building Systems.
   "14K Hy Flow," BASF Building Systems
   “588 Grout”, W. R. Meadows
   “US Spec MP Grout”, US Mix Co.

AA. Frictionless Bearing Pads:

1. Types:

a. Frictionless bearing pads shall be a nominal 3/32" glass filled virgin Tetrafluoroethylene (TFE) conforming to ASTM D 4745 with a 10 gauge A36 steel backing plate factory bonded with a tested epoxy performed in a heated bonding process under a controlled pressure. Provide one sliding pad tack welded to the lower supporting surface and one tack welded to the upper surface. Unless detailed otherwise on the drawings, the upper element shall be larger than the lower element on all sides by the amount of the expansion joint width shown on the drawings.

b. The lower frictionless bearing pads shall be a nominal 1/16" glass filled virgin Tetrafluoroethylene (TFE) conforming to ASTM D 4745 with a 10 gauge A36 steel backing plate factory bonded with a tested epoxy performed in a heated bonding process under a controlled pressure. The upper frictionless bearing pad shall be a 20 gauge stainless steel sheet (RMS<20) resistance welded to a 10 gauge A36 steel backing plate. The lower sliding pad shall be tack welded to the lower supporting surface and the upper pad tack welded to the upper surface. Unless detailed otherwise on the drawings, the upper element shall be larger than the lower element on all sides by the amount of the expansion joint width shown on the drawings.

2. Design: The pad size and design shall conform to 1998 AASHTO "LRFD Bridge Design Specifications," Section 14. Design bearing pressure under total service load shall not exceed the manufacturer's recommendation. If Neoprene is used the compressive load shall be limited to 800 psi.

3. Corrosion Resistance: Frictionless bearing pads for exterior or exposed usage shall be manufactured for use in an exposed climate of heat, cold, moisture, and ultraviolet rays. All backing steel in an exposed or open environment shall be shop painted with a zinc rich paint or field painted with "ZRC Cold Galvanizing Compound".

4. Acceptable Manufacturers: The following manufacturers are acceptable:

a. Con-Serv, Inc., Georgetown, SC
b. Seismic Energy Co., Athens, TX

Other manufacturers will be acceptable only with Engineer approval prior to bid.

BB. Steel Fibers: Provide deformed cold-drawn wire or modified cold-drawn steel fibers meeting the requirements of ASTM A 820, types I or V, and that are listed as an acceptable product for use in the D900 series of UL Fire Rating Assemblies. The fibers shall have a minimum tensile strength of 145,000 psi when tested in accordance with ASTM A 370. The fibers shall have a minimum aspect ratio of 48. Acceptable products include:

"Dramix RC-65/60-BN" (Type 1), "Dramix RL45/50BN" (Type I), Dramix ZL60/1.05" (Type 1), Bekaert Corp.
"Novocon 1050" (Type I), Novocon 1050 HE" (Type I), or "Novomesh 850" (Type I), Propex Concrete Systems, Corp.
"MasterFiber FF or FS" series, BASF Construction Chemicals

CC. Synthetic Micro Fiber Reinforcement: Collated, fibrillated, or monofilament polypropylene, cellulose, or multi-filament nylon fibers conforming to ASTM C 1116, Type III or Type IV.

Products:

"Fiberstrand", the Euclid Chemical Company
"Econo-Mono" or "Econo-Net"; Forta Corp.
"Fibermesh 300"; Propex Concrete Systems, Corp.
"Grace Microfibers" or "Grace Fibers", W.R. Grace & Co.
"Caprolan-RC", Honeywell Nylon Inc.
"Nycon RC", Nycon, Inc.
"UltraFiber 500", Buckeye Technologies, Inc.
"MasterFiber M or F" series, BASF Construction Chemicals

DD. Synthetic Macro Fiber Reinforcement: Monofilament polypropylene/polyethylene fibers conforming to ASTM C 1116, Type III having an aspect ratio between 50 and 90 and a minimum tensile strength of 90 ksi. The fiber lengths shall be between 1.5 and 2 inches long.

Products:

"Tuf-Strand S.F.", the Euclid Chemical Company
"Forta-Ferro", Forta Corp.
"Strux 90/40", W.R. Grace
"Fibermesh 650", Propex Concrete Systems, Corp.
"Synmix", Bekaert Corp.
"MasterFiber MAC" series, BASF Construction Chemicals

EE. Reglets: Where resilient or elastomeric sheet flashing or bituminous membranes are terminated in reglets, provide reglets of not less than 26 gage galvanized sheet steel. Fill reglet or cover face opening to prevent intrusion of concrete or debris.

FF. Carton Forms: Carton forms shall be manufactured using corrugated paper material with a moisture resistant exterior surface and specifically designed for foundation support. Carton forms shall be designed to support the wet weight of the concrete that is shown by the details to be poured on top of the form but not less than 600 psf. Refer to the Reinforced Concrete General Notes for the restriction on horizontal construction joints. The forms shall be designed in such a way that the bottom of the form will collapse when acted upon by upward movement of the soil.

1. Form Configuration: Carton forms shall be of a vertical cellular configuration only, except as permitted by item 4 below, and shall be rectangular as shown on the details. The depth of the carton forms is shown on the details. Forms shall be manufactured to fit snugly against round piers and shall be baffled in such a way as to prevent concrete from flowing back into the form during the concrete pour. The Contractor shall use expandable foam to fill all gaps and holes between carton forms and at intersections with foundations.

2. Carton forms shall be kept dry and protected until concrete is poured. Wet, compressed, or deteriorated carton forms shall not be used. Do not wrap or cover carton forms with polyethylene sheets or permanent waterproof cover as that will prevent proper deterioration of the forms.

3. Technical data and brochures on carton forms shall be submitted for Engineer's review.

4. Other types of forms using different types of paper and different configurations will be accepted if it can be shown by independent tests that the form will properly function and will deteriorate due to moisture in an appropriate time frame.

5. For slab conditions, cover carton forms with a 1/4 inch masonite protection cover board to prevent puncture and other damage during construction.

6. Products: Subject to requirements, acceptable manufacturers include but are not limited to the following:

SureVoid Products, Inc., Englewood, CO

GG. Contraction and Construction Joint-Filler Material for Slabs-on-Grade: Provide a 2-component semi-rigid, 100% solids epoxy having a minimum shore A hardness of 80 when tested in accordance with ASTM D 2240 and an elongation below 25% when measured in accordance with ASTM D 638. Subject to compliance with requirements, provide one of the following:

"Euco 700", the Euclid Chemical Company
"Spec-Joint CJ"; Conspec Marketing and Manufacturing Co., Inc.
"Masterfill 300 I", BASF Building Systems
"MM-80", Metzger/McGuire Co.
"Rezi-Weld Flex", W. R. Meadows
"US Spec SR-50 EJF", US Mix Co.

HH. Bond breaker for Construction Joints in Slabs-on-Grade: A dissipating bond breaking compound containing no silicones, resins, or waxes, and that conforms to ASTM C 309. Subject to compliance with requirements, acceptable manufacturers include the following:

"Sure-Lift", Dayton Superior Corporation, Inc.
"Tilt-Eez", Conspec Marketing and Manufacturing Co., Inc.

II. Joint-Filler Strips for Isolation Joints in Slabs-on-Grade: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork. In post-tensioned slabs or shrinkage-compensated slabs, use compressible isolation-joint filler material that does not develop a stress greater than 25 psi at 50% strain when tested in accordance with ASTM D 1621 or D 3575.

JJ. Rigid-Cellular-Polystyrene Boards use as Fill under Topping Slabs or Slabs-on-Grade: Provide rigid, expanded (EPS) or extruded (XPS) cellular polystyrene boards that conform to ASTM D 6817 or ASTM C 578 with a minimum density of [Polystyrene Density] kg/m^3. Subject to compliance with requirements, acceptable manufacturers include the following:

"STYROFOAM Brand" Dow Chemical Company
"R-Control EPS Geofoam" - All grades, R-Control Building Systems
"EPS Geofoam", Carpenter Co.
"Knauf Geofoam", Knauf Polystyrene
"Insulfill", Premier Industries

2.3 PROPORTIONING AND DESIGN OF CONCRETE MIXES

A. The Contractor shall submit concrete mix designs and the Concrete Mix Design Submittal Form located at the end of this specification section for each class of concrete indicated on the structural drawings and in the Specifications for approval by the Engineer and Owner's Testing Laboratory at least 15 working days prior to the start of construction,. If required, the Contractor shall engage the services of an independent Testing Laboratory to assist in preparing the mix design. The Contractor shall not begin work with a particular mix until that mix design has been approved.

B. Mix Design Conference: See the PREINSTALLATION CONFERENCES section of this specification.

C. The Contractor, acting in conjunction with his Concrete Supplier and his Testing Laboratory, shall submit in writing, with his mix designs, the method used to select mix proportions. Either of the following methods, as outlined in ACI 301, may be used.

1. Field Experience Method

2. Laboratory Trial Mixture Method

D. Required types of concrete and compressive strengths shall be as indicated on the Structural Drawings.

E. All mix designs shall state the following information:

1. Mix design number or code designation by which the Contractor shall order the concrete from the Supplier.

2. Structural slab or member for which the concrete is designed (i.e., columns, shear walls, footings, slab on grade, etc.).

3. Wet and dry unit weight.

4. 28 day compressive strength.

5. Aggregate type, source, size, gradation, fineness modulus.

6. Cement type and brand.

7. Fly ash or other pozzolan type and brand (if any).

8. Admixtures including air entrainment, water reducers, high-range water reducers, accelerators, and retarders.

9. Design Slump or Slump/Flow.

10. Proportions of each material used.

11. Water/cementitious ratio and maximum allowable water content.

12. Method by which the concrete is intended to be placed (bucket, chute, or pump).

13. Required average strength qualification calculations per ACI 301 4.2.3.3a and 4.2.3.3b. Submit separate qualification calculations for each production facility that will supply concrete to the project.

14. Documentation of Average strength (trial mix data or field test data) per ACI 301: When field test data is used to qualify average strength, submit separate documentation for each production facility that will supply concrete to the project.

15. Field test data submitted for qualification of average strength under ACI 301 shall include copies of the Concrete Testing Labratory's reports from which the data was compiled.

16. All other information requested in the Concrete Mix Design Submittal Form located at the end of this specification section.

F. Low Alkali Concrete: For concrete identified on the drawings as exposed to exposure classes C1 and C2, the total alkali contribution from cementitious materials in the concrete mix shall not exceed 4.0 pounds per cubic yd of concrete unless the aggregate used is certified to contain no deleterious materials that react with alkalis in the concrete mix as defined in ASTM C 33. This requirement may be met by the use of low-alkali cement.

G. Supplementary Cementitious Materials: Fly ash and/or ground granulated blast-furnace slag replacement of Portland cement shall be within percentage replacement levels listed on the drawings unless noted otherwise. Every effort should be made to reduce the amount of cement to the minimum practical amount, and still achieve performance requirements contained in the Contract Documents.

1. Cement replacement shall not exceed a percentage level that has been shown by experience on other projects to exhibit satisfactory performance using materials from identical sources as proposed for this project. As an alternate, trial concrete batches can be performed to identify mix designs that maximize cement replacement while meeting strength requirements per ACI 318 Section 5.3 and finishability criteria.

2. The use of fly ash or slag in architecturally exposed structural concrete shall be coordinated with the Architect, Engineer of Record, and Contractor.

3. If fly ash is used, it must be at a minimum replacement percentage of 15%.

4. Overall replacement percentages with combined fly ash and slag shall not exceed the maximum identified with slag or be less than the minimum identified with fly ash for each type of element. In addition, the replacement percentage of fly ash within the combined mix shall not exceed the maximum identified with fly ash alone.

5. Replacement percentages exceeding the maximum may be permitted at the discretion of the Architect, Engineer of Record, and Contractor.

6. For concrete identified on the drawings as being subject to Exposure Class F3, the maximum amount of supplementary cementitious materials shall not exceed the limits noted in table 4.4.2 of ACI 318-08

7. Except for Mass Concrete, the Contractor may submit for approval a revised mix design with lower supplementary cementitious material percentages than herein specified should finishability or other issues arise due to changing weather conditions.

H. Aggregate: Comply with the following special requirements:

1. For exposed concrete, provide aggregates from a single source.

2. For exposed surfaces subject to Exposure Class C1 or C2, do not use aggregates containing spalling-causing deleterious substances.

3. For slabs and other designated concrete, combined aggregate gradation shall be 8% - 18% for large top size aggregates (1 1/2 in.) or 8% - 22% for smaller top size aggregates (1 in. or 3/4 in.) retained on each sieve below the top size and above the No. 100. Deviations from this gradation may be allowed upon the approval of the Engineer subject to the following limitations:

   a. The percent retained on two adjacent sieves shall be not less than 5%.
   b. The percent retained on three adjacent sieves shall be not less than 8%
   c. If the percent retained on two adjacent sieves is less than 8%, the total percent retained on either of those sieves and the adjacent outside sieve shall be not less than 13 %

I. Admixtures:

1. Admixtures to be used in concrete shall be subject to the approval of the Engineer and Owner's Testing Laboratory and shall be used for the purpose intended by the manufacturer to produce concrete to meet the specified requirements.

2. Quantities of admixtures to be used shall be in strict accordance with the manufacturer’s instructions.

3. Air Content Requirements: For concrete subject to Exposure Class F1, F2 or F3 as noted on the drawings, use air-entrainment admixtures to provide concrete such that the air content at the point of delivery shall conform to the requirements of Table 4.4.1.of ACI 318-08 within plus or minus 1.5%. Required air content levels may be reduced by 1.0 percent for concrete strengths above 5000 psi.

   a. Interior steel troweled surfaces subjected to vehicular traffic shall not have more than 3% entrained air.
   b. Surfaces scheduled to receive hardeners shall not have more than 3% entrained air.
   c. Air-entraining admixtures are not permitted in industrial slabs.

4. Self-consolidating Concrete (SCC): Use where shown on the drawings. Proportion SCC mix with specified admixtures to produce a concrete having properties that allow it to flow freely into all spaces of the formwork, through tight openings under its own weight and is resistant to segregation during transport and placing. Flowable spread shall be between 20 to 30 inches and shall show no evidence of segregation, mortar halo, or aggregate pile, although some slight bleeding is acceptable. Workability, pumpability, finish, and setting time of the proposed mix design must be demonstrated by a successful trial placement onsite.

J. Lightweight Structural Concrete:

1. Comply with the requirements of ACI 211 and ACI 301.

2. Provide concrete with a dry unit weight of not more than 116 pounds per cubic foot and not less than 110 pounds per cubic foot. Design mix to produce strengths as indicated on the drawings with a split cylinder strength factor $(fct/(f'c)^{0.5})$ of not less than 5.7.

K. Adjustments of Concrete Mixes: Mix design adjustments may be requested by the Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant. Such mix design adjustments shall be provided at no additional cost to the Owner. Any adjustments in approved mix designs including changes in admixtures shall be submitted in writing with the specified Concrete Mix Design Submittal Form to the Engineer and Owner's Testing Laboratory for approval prior to field use.

L. Shrinkage: Concrete so identified on the drawings shall be proportioned for maximum allowable unit shrinkage as noted on the drawings, measured at 28 days after curing in lime water as determined by ASTM C 157 (using air storage). Submit results of test for each class of applicable concrete after every 500 CY placed.

M. Chloride Ion Content:

1. Unless noted otherwise, The maximum water soluble chloride ion concentration in hardened concrete measured at ages from 28 to 42 days contributed from all ingredients including water, aggregates, cementitious materials, and admixtures shall not exceed the limits specified in ACI 318-08 Table 4.3.1 depending on to which Corrosion Exposure Class (CO, C1 or C2) the concrete is subject as noted on the drawings. Water-soluble chloride ion tests shall conform to ASTM C 1218. One test shall be run for each class of concrete before the mix design submittal and each time a change is made to the mix design (such as change in aggregate type or source).

2. The chloride ion content in all concrete used for prestressed or post-tensioned concrete shall not exceed .06 percent by weight of cement.

3. The Concrete Supplier shall certify on the Mix Design Submittal Form that the chloride ion content in all concrete mix designs used on the project does not exceed the limits stated above.

2.4 CONCRETE MIXING

A. Ready-Mix Concrete: Comply with requirements of ANSI/ASTM C 94, "Ready Mixed Concrete" and Testing Laboratory section of the specifications this specification .

PART 3 - EXECUTION

3.1 SLUMP LIMIT

A. The slump, as measured in the field where concrete cylinders are taken, shall be within plus or minus 1 inch of the design slump noted on the Mix Design Submittal Form. Self-consolidating concrete shall have a slump/flow of plus or minus 2 inches of the design slump noted on the Mix Design Submittal Form. Water may be added to the concrete in

the field only to the extent that the prescribed water/cementitious ratio noted in the Mix Design Submittal Form is not exceeded.

3.2 VAPOR RETARDER INSTALLATION

A. Install vapor retarder in accordance with ASTM E 1643 and manufacturer's instructions.

B. Lap all seams 6" and seal all joints in the field with the specified pressure sensitive tape. Heat-welded joints done in a shop prior to delivery is an acceptable method to minimize the number of field joints.

C. Seal all pipe penetrations through the vapor retarder with a boot made from the vapor retarder material and tape.

3.3 JOINTS IN CONCRETE

A. 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. Keyways: Provide continuous keyways with a depth of one tenth of the member thickness (1 1/2" minimum or as shown on the drawings) in construction joints only where shown on the drawings.

2. Joint Construction: Place construction joints in the center one third of suspended spans and grade beams and as shown on the drawings for slabs-on-grade and walls unless shown otherwise. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise shown on the drawings. Dowels that cross construction joints shall be supported during concreting operations so as to remain parallel with the slab or wall surface and at right angles to the joint. Submit all construction joint locations as a shop drawing submittal.

3. Waterstops: Provide waterstops in construction joints as indicated on the Architectural and Structural Drawings. Install waterstops to form continuous diaphragm in each joint. Make provisions to support and protect exposed waterstops during progress of work. Fabricate field joints in waterstops in accordance with manufacturer's printed instructions.

4. Isolation Joints in Slabs-on-Ground: 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. Install joint-filler strips at joints where indicated. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated on the drawings. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together. Provide construction joints with dowels at all locations unless isolation joints are detailed.

5. Contraction joints in slabs-on-grade and unbonded topping slabs: Maximum joint spacing shall be 36 times the slab thickness or 20 feet, whichever is less and at a minimum on column lines unless otherwise noted on the drawings. Use one of the two following methods (sawed or formed) to create the joints. Do not use the formed joint in areas subject to vehicular traffic or in industrial slabs.

a. Sawed Joints
   (1) Primary Method: Early-Entry, dry-cut method, by Soff-Cut International, Corona, CA (800) 776-3328. Finisher must have documented successful experience in the use of this method prior to this project. Install cuts within 1 to 4 hours, depending on air temperature, after final finish as soon as the concrete surface is firm enough to not be torn or damaged by the blade at each saw cut location. Use 1/8 inch thick blade, cutting 1 1/4" inch into the slab.
   (2) Optional Method (where Soff-Cut System method equipment is not available, subject to limitations): This method may not be used when there is no dowel passing through the contraction joint. Use a conventional saw to cut joints within 4 to 12 hours after finishing as soon as the concrete has hardened sufficiently to prevent aggregates from being dislodged by the saw. Complete cutting before shrinkage stresses become sufficient to produce cracking. Use 1/8 inch thick blade, cutting to a depth of 1/4 of the slab thickness but not less than 1 inch. Cut to a depth of 1/3 slab thickness for slabs reinforced with steel fibers.

b. Formed Joints: Form contraction joints by inserting premolded plastic hardboard or fiberboard strip into fresh concrete until top surface of strip is flush with slab surface. The depth is to be 1/4 the slab thickness, but not less than 1 inch. Tool slab edges round on each side of insert. After concrete has cured, remove inserts and clean groove of loose debris.

c. Joint Filler: Provide in both contraction and saw-cut construction joints when specified.
   (1) Remove dirt and debris from the joint by vacuuming immediately prior to filling the joint. Clean the joint of curing compounds and sealers.
   (2) Filler material shall be applied to the joints when the building is under permanent temperature control, but no less than 90 days after slab construction.
   (3) Follow the manufacturer's recommended procedure for installing filler material. The joint filler must be flush with the adjacent concrete. A concave profile on the top of the joint filler is unacceptable and will be grounds for removal and replacement.

d. The Contractor shall protect the joints from damage caused by wheeled traffic or other sources during construction until a joint-filler material (if specified) has been installed.

3.4 INSTALLATION OF EMBEDDED ITEMS

A. General: Set and build into work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete. Use setting drawings, diagrams, instructions and directions provided by suppliers of items to be attached thereto unless directed otherwise by these specifications. Install reglets to receive top edge of foundation sheet waterproofing where specified by the Architect, and to receive thru-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, relieving angles and other conditions.

B. Anchor Rods: Furnish anchor rods and other connectors required for securing structural steel to foundations and other in-place work as shown on the drawings. Furnish 1/8" minimum steel templates for presetting rods and other anchors to accurate locations as shown on the drawings in keeping with the tolerances noted in ACI 117 for embedded anchor rods. Steel template shall be clearly marked with the following information:

1. Grid line intersection where template is to be used.

2. Orientation of the plate relative to the building grid lines.

3. “Top of Template” elevation.

4. Anchor rod projection above top of template.

C. Edge Forms and Screed Strips for Slabs: Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in finished slab surface. Provide and secure units sufficiently strong to support types of screed strips by use of strike-off templates or accepted compacting type screeds.

D. Do not install sleeves and blockouts in concrete slabs, pier caps, footings or walls except where shown on the structural drawings or approved by the Architect and Engineer.

E. Securely fasten embedded plates, angles, anchor rods and other items to be built into the concrete to the formwork or hold in place with templates. Insertion of these items into concrete after casting is prohibited.

3.5 CONCRETE PLACEMENT

A. Pre-placement Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel and items to be embedded or cast-in. Notify other crafts to permit installation of their work; cooperate with other trades in setting such work. Moisten wood forms immediately before placing concrete where form coatings are not used.

B. Coordinate the installation of joint materials and vapor retarders with placement of forms and reinforcing steel.

C. Comply with ACI 301 and as herein specified.

1. Concrete Temperature: The maximum acceptable concrete temperature at the truck discharge point shall be 95 °F.

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 to its final location to avoid segregation. Spread concrete using short-handled, square-ended shovels, or come-alongs.

3. Placing Concrete in Forms: Deposit concrete in forms in horizontal layers not 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. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping. Use internal vibrators of the largest size and power that can properly be used in the work as described in the table entitled “Range of characteristics, performance, and applications of internal vibrators” found in ACI 301.

5. 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.

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. Place concrete for beams, girders, brackets, column capitals, haunches, and drop panels at the same time as concrete for slabs. Do not place concrete over columns and walls until concrete in columns and walls is no longer plastic and has been in place at least one hour.

7. Consolidate concrete during placing operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners of forms, eliminating air and stone pockets that may cause honeycombing, pitting, or planes of weakness.

8. Bring slab surfaces to correct level with straightedge and strikeoff. Use highway straightedges, bull floats or darbies to smooth surface free of humps or hollows before excess moisture or bleedwater appears on the surface. Do not disturb slab surfaces prior to beginning finishing operations.

9. Maintain reinforcing in proper position during concrete placement operations.

10. Placing Concrete by Pump: If concrete is placed by using a pump, the grout used for pump priming must not become a part of the completed structure unless an engineered grout design mix and grout location are approved in advance by the Engineer.

3.6 FINISH OF FORMED SURFACES

A. General: Formed surfaces shall have the finishes as described below and as shown on the drawings after formwork is removed and repairs made.

B. Matching Sample Finish: Finish on surfaces at locations noted on drawings shall match sample panel furnished to Contractor. Reproduce finish on a 100 square foot mock-up panel in a location designated by Architect/Engineer. Protect mock-up from damage for the duration of project. Approval of mock-up by Architect is required before proceeding with application of finish in project.

C. Definitions and Finish Requirements

1. Surface Finish 1.0 (SF-1.0):

a. No formwork facing material is specified
b. Patch voids larger than 1-1/2 in. wide or 1/2 in. deep
c. Remove projections larger than 1.0 inch.
d. Provide surface tolerance Class D as specified in ACI 117
e. Tie holes need not be patched

2. Surface Finish 1.1 (SF-1.1):

a. No formwork facing material is specified
b. Patch voids larger than 1 in. wide or 1/2 in. deep

c. Remove projections larger than 1/2 inch.
d. Provide surface tolerance Class C as specified in ACI 117
e. Tie holes need not be patched

3. Surface Finish 2.0 (SF-2.0):

a. Provide specified formwork-facing material
b. Patch voids larger than 3/4 in. wide or 1/2 in. deep
c. Patch tie holes
d. Remove projections larger than 1/4 in.
e. Provide surface tolerance Class B as specified in ACI 117
f. Provide mock-up of concrete surface appearance.

4. Surface Finish 2.1 (SF-2.1):

a. Provide specified formwork-facing material
b. Patch voids larger than 3/4 in. wide or 1/2 in. deep
c. Patch tie holes
d. Remove projections larger than 1/4 in.
e. Provide surface tolerance Class B as specified in ACI 117
f. Provide specified rubbed finish after formwork removal
g. Provide mock-up of concrete surface appearance.

5. Surface Finish 2.2 (SF-2.2):

a. Provide specified formwork-facing material
b. Patch voids larger than 3/4 in. wide or 1/2 in. deep
c. Patch tie holes
d. Remove projections larger than 1/4 in.
e. Provide surface tolerance Class B as specified in ACI 117

6. Surface Finish 2.3 (SF-2.3):

a. No formwork-facing material is specified
b. Patch voids larger than 3/4 in. wide or 1/2 in. deep
c. Patch tie holes
d. Remove projections larger than 1/4 in.
e. Provide surface tolerance Class B as specified in ACI 117

7. Surface Finish 3.0 (SF-3.0):

a. Provide specified formwork facing material
b. Patch voids larger than 3/4 in. wide or 1/2 in. deep
c. Remove projections larger than 1/8 inch.
d. Patch tie holes
e. Provide surface tolerance Class A as specified in ACI 117
f. Provide mock-up of concrete surface appearance.

8. Surface Finish 3.1 (SF-3.1):

a. Provide specified formwork-facing material
b. Patch voids larger than 3/4 in. wide or 1/2 in. deep
c. Patch tie holes
d. Remove projections larger than 1/8 in.
e. Provide surface tolerance Class A as specified in ACI 117

f. Provide specified rubbed finish after formwork removal
g. Provide mock-up of concrete surface appearance.

9. Surface Finish 3.2 (SF-3.2):

a. Provide specified formwork-facing material
b. Patch voids larger than 3/4 in. wide or 1/2 in. deep
c. Patch tie holes
d. Remove projections larger than 1/8 in.
e. Provide surface tolerance Class A as specified in ACI 117

10. Surface Finish 3.3 (SF-3.3):

a. No formwork-facing material is specified
b. Patch voids larger than 3/4 in. wide or 1/2 in. deep
c. Patch tie holes
d. Remove projections larger than 1/8 in.
e. Provide surface tolerance Class A as specified in ACI 117

D. Standard Finish: Provide SF-1.0 on all concrete surfaces not exposed to view in the final condition unless otherwise specified.

E. Exposed Finishes: Provide SF-2.0 on all concrete surfaces exposed to view in final condition unless otherwise specified.

F. Rubbed Finishes: Remove forms as early as permitted by these specifications and perform any necessary repairs and patches.

1. Smooth Rubbed Finish: Provide smooth rubbed finish to scheduled or specified 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.

2. Grout Cleaned Finish: Provide grout cleaned finish to scheduled or specified concrete surfaces that have received smooth-form finish treatment.

a. Combine one part portland cement to 1-1/2 parts sand meeting the requirements of ASTM C144 and C404 by volume, and 50:50 mixture of acrylic or styrene butadiene based bonding admixture and 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.

3. Cork-floated Finish: Provide cork-floated finish to scheduled or specified concrete surfaces that have received smooth-form finish treatment.

a. Combine one part portland cement to one part sand meeting the requirement of ASTM C144 or C404, by volume and water and mix to a to consistency of thick paint. Apply stiff to a wet surface, compressing the grout into all voids.
b. Produce the final finish with a cork float using a swirling motion.

G. Self-Consolidating Concrete Architectural Finish: Use self-consolidating concrete where shown on the plans to produce a smooth, uniform finish upon form removal with no patching, stoning, rubbing or other form of repair, except washing, permitted. The surface shall match the approved jobsite test panel.

H. Related Unformed Surfaces: At tops of walls, horizontal offsets and similar unformed 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.

3.7 MONOLITHIC SLAB FINISHES

Place, consolidate, strike off, and level concrete, eliminating high spots and low spots, before proceeding with any other finish operation. Do not add water to the surface of the concrete during finishing operation.

A. 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. After placing slabs, plane surface to tolerance specified below. Slope surfaces uniformly to drains where required. After leveling, roughen surface before final set, with stiff brushes, brooms or rakes.

B. 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. After screeding, consolidating and leveling concrete slabs, do not work surface until ready for floating. Begin floating, using a hand float, a bladed power float equipped with float shoes, or a powered disk float, when the bleed water sheen has disappeared and the concrete surface has stiffened sufficiently to permit the operation. 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.

C. 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 by hand or 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.

D. Trowel and Fine Broom Finish: Where ceramic or quarry tile is to be installed with thin-set mortar, apply initial trowel finish as specified above, then immediately follow with slightly scarifying surface by fine brooming.

E. Slip-Resistive Broom Finish: Apply slip-resistive broom finish to garage floors and ramps less than 6% slope, exterior concrete platforms, steps and ramps and elsewhere as indicated. Immediately after float finishing, slightly roughen concrete surface by

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

F. Roller-Bug Finish: Provide a roller-bug finish with minimum ¼" amplitude to all ramps exceeding a 6% slope. Extend the finish as least 12 feet beyond the beginning and ending of the greater-than-6% ramp. The finish shall be imprinted on the concrete by the use of a roller-bug tamper.

G. Chemical-Hardener Finish: Apply chemical-hardener finish to interior concrete floors where indicated. Apply liquid chemical-hardener after complete curing and drying of the concrete surface. Apply proprietary chemical hardeners, in strict accordance with manufacturer's printed instructions.

After final coat of chemical-hardener solution is applied and dried, remove surplus hardener by scrubbing and mopping with water.

H. Liquid Sealer/Densifier Finish: Apply liquid sealer/densifier finish to exposed interior concrete floors where indicated. Apply liquid sealer/densifier after complete curing and drying of the concrete surface and in strict accordance with manufacturer's printed instructions.

I. Penetrating Sealer Finish: Apply a chloride-and-water-repelling-penetrating-sealer finish to surfaces as described below and where indicated on the drawings. Apply liquid penetrating sealer after complete curing and drying of the concrete surface. Apply proprietary sealers in strict accordance with manufacturer's printed instructions. The Contractor shall verify the compatibility of the sealer product with the paint used to stripe parking decks and coordinate the sequencing of the sealing and striping operations. Apply to the following surfaces:

1. Sloping and horizontal surfaces of parking garages

2. Top surfaces of exposed exterior balconies

J. Slip-Resistive Aggregate Finish: Apply slip-resistive aggregate finish to concrete stair treads, platforms, ramps and elsewhere as indicated on the Architect's or Structural Drawings.

After completion of float finishing, and before starting trowel finish, uniformly spread 25 lbs. of dampened slip-resistive 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 slip-resistive aggregate.

K. Colored, Mineral Aggregate Surface Hardener: Provide colored, mineral aggregate surface hardener to monolithic slab surface indicated.

Apply dry shake materials for colored wear-resistant finish at rate of not less than 100 lbs. per 100 sq. ft., unless greater amount is recommended by material manufacturer.

Cast a trial slab approximately 20 feet square to determine actual application rate, color and finish as acceptable to Architect/Engineer.

Immediately following first floating operation, uniformly distribute approximately 2/3 of required weight of dry shake material over concrete surface, and embed by means of power floating. Follow floating operation with second shake application, uniformly distributing remainder of dry shake material at right angles to first application, and embed by power floating.

After completion of broadcasting and floating, apply trowel finish as herein specified. Cure slab surface with curing compound recommended by dry shake hardener manufacturer. Apply curing compound immediately after final finishing.

L. Non-Oxidizing Metallic Floor Hardener: Slabs in areas noted on the drawings shall receive an application of the non-oxidizing, metallic floor hardener applied at the rate of 150 lbs. Per 100 sq. ft. Immediately following the first floating operation, uniformly distribute approximately 2/3 of the required weight of the hardener over the concrete surface by mechanical spreader and embedded by means of power floating. The hardener shall be floated in and the second application made. The surface shall be floated again to properly bond the hardener to the base concrete slab. The surface shall then be troweled at least twice to a smooth dense finish.

M. Metallic Aggregate Floor Hardener: Slabs in areas noted on the drawings shall receive an application of the metallic aggregate floor hardener applied at the rate of 150 lbs. Per 100 sq. ft. Immediately following the first floating operation, uniformly distribute approximately 2/3 of the required weight of the hardener over the concrete surface by mechanical spreader and embedded by means of power floating. The hardener shall be floated in and the second application made. The surface shall be floated again to properly bond the hardener to the base concrete slab. The surface shall then be troweled at least twice to a smooth dense finish.

N. Finish of Top of Spread Footings and/or Mat Foundations:

1. Top Surface below Finished Slab: The top of the footing or mat shall be screeded level and smooth with a flatness F-number, F_F15 (overall), F_F10 (minimum local) and a levelness F-number, F_L12 (overall), F_L10 (minimum local).

2. Top Surface as Finished Slab: The top surface of a footing or mat that is to serve as the finished slab in the building shall be leveled cured, and surface prepared as specified for the finished floor construction appropriate to the space usage as defined in the Architectural Drawings.

3.8 CONCRETE FINISH MEASUREMENT AND TOLERANCES

A. Testing Procedure: ASTM E 1155

B. Tolerance on Floor Elevations: Construction tolerance on absolute floor elevation from the specified elevation as shown on the drawings shall be as specified below, taken from ACI 117:

1. Slab-on-Grade Construction - $\pm$ 3/4".

2. Top surfaces of formed slabs measured prior to removal of supporting shores - $\pm$ 3/4".

3. Top surfaces of all other slabs - $\pm$ 3/4".

C. Random Traffic Floor Finish Tolerances:

1. Specified overall values for flatness (SOF_F) and levelness (SOF_L) shall conform to the values listed below for the floor surface classification noted for each slab category noted.

Floor Surface Classification	SOF_F	SOF_L
Conventional	20	15
Moderately Flat	25	20
Flat	35	25
Very Flat	45	35
Super Flat	60	40

2. Minimum local values for flatness (MLF_F) and levelness (MLF_L) shall equal 3/5 of the SOF_F and SOF_L values, respectively, unless noted otherwise. The MLF_F and MLF_L values shall apply to the minimum areas bounded by the column lines and half-column lines, or the minimum areas bounded by the construction and contraction joints, whichever are the smaller areas.

3. The SOF_L and MFL_L tolerance values shall apply only to level slabs-on-ground or to level, uncambered suspended slabs that are shored such that it cannot deflect from the time the floor is placed to the time it is measured.

4. Slabs specified to slope shall have a tolerance from the specified slope of 3/8" in 10 feet at any point.

D. Construction Requirements to Achieve Specified Floor Finish Tolerances:

1. Forms shall be properly leveled, in good condition and securely anchored including special attention to ends and transitions.

2. Bearing surfaces for straightedges such as form edges or previously poured slabs shall be kept clean of laitance, sand, gravel, or other foreign elements.

3. Screeds shall be maintained in good condition with true round rolling wheels and level cutting edges. The use of optical sighting equipment such as lasers is recommended for checking levelness and straightness. The Contractor shall promptly adjust or replace equipment when test results indicate substandard work.

4. Highway straightedges are recommended for use in lieu of bullfloats for all slab placement and finishing operations.

E. Contractor Responsibility for Concrete Floor Finish Requirements: Floor finish requirements shown below (flatness and levelness tolerances) are minimum requirements that apply unless stricter requirements are contained in instructions for installation of applied floor products in which case the Contractor is responsible for attaining the values prescribed by the manufacturer of such products.

F. Concrete Floor Finish Tolerance for Slab-on-Grade Construction:

1. Concrete Placement: Concrete shall be placed and screeded to predetermined marks set to elevations prescribed on the drawings.

2. Finish Tolerances of Random Traffic Floor Surfaces:

    a. Slabs in nonpublic areas, mechanical rooms, surfaces to received raised computer flooring, surfaces to have thick-set tile or a topping, and parking structures: Conventional
    b. Carpeted Areas: Moderately Flat
    c. Industrial Slabs: Moderately Flat
    d. Exposed slabs in public spaces, slabs to receive thin-set flooring: Flat
    e. Ice or Roller rinks: Very Flat
    f. Movie or Television studios: Super Flat
    g. Gymnasium Floors Scheduled to Receive Wood Playing Floor: Very Flat

G. Concrete Floor Finish Tolerance for Shored, Cast-in-Place Suspended Slab Construction:

1. Concrete Placement: Formwork shall be set and securely braced so that soffits are positioned to allow scheduled concrete member sizes and thicknesses within tolerances specified in ACI 117. Concrete shall be placed and screeded to predetermined marks on the form surface conforming to elevations prescribed on the drawings.

2. Camber: Formwork camber, as indicated on the drawings, shall be set to provide a uniform, smooth soffit profile in each direction. Minimum slab thickness, as specified on the drawings, shall be maintained throughout the slab surface to a tolerance as specified in ACI 117. Tolerance on camber shall be $\pm$ 1/4". Levelness F-Number tolerances specified below does not apply to areas of the floor where camber or intentional slope is shown.

3. Finish Tolerances of Random Traffic Floor Surfaces:

    a. Slabs in nonpublic areas, mechanical rooms, surfaces to received raised computer flooring, surfaces to have thick-set tile or a topping, and parking structures: Conventional
    b. Carpeted Areas: Moderately Flat
    c. Exposed slabs in public spaces, slabs to receive thin-set flooring: Flat
    d. Movie or Television studios: Super Flat

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

5. Concrete Placement at Column Bays Supported by unshored transfer girders: Concrete in floor areas supported by unshored transfer girders shall be placed and screeded to predetermined marks placed over the slab conforming to elevations as specified on the drawings. At least the minimum slab thickness, as specified on the drawings, shall be maintained throughout the slab surface. The Contractor shall conform to the F_F values specified above.

H. Concrete Floor Finish Tolerance - Unshored Metal Deck on Shored or Unshored Steel Beam or Open-Web Joist Floor Construction:

1. Concrete Placement: Concrete over metal deck shall be placed and screeded level and flat to the tolerance specified below, maintaining at least the minimum slab thickness at all locations as specified on the drawings. The Contractor shall increase the slab thickness as required to compensate for metal deck deflection, and in unshored beam construction, residual beam camber and beam deflection in order to achieve a level and flat floor within specified tolerances.

2. Finish Tolerance of Random Traffic Floor Surfaces:

   a. Slabs in nonpublic areas, mechanical rooms, surfaces to received raised computer flooring, surfaces to have thick-set tile or a topping, and parking structures: Conventional
   b. Carpeted Areas: Moderately Flat
   c. Exposed slabs in public spaces, slabs to receive thin-set flooring: Flat
   d. Movie or Television studios: Super Flat
   e. Eighty percent (80%) of the final floor surface shall fall within an envelope of 0.75" centered about the mean elevation of all the readings. (± 0.375 about mean). The mean elevation of all readings shall not deviate from the specified design grade by more than ± 0.375".

3. Extra Concrete: The contractor shall include in his bid any additional concrete required to achieve the specified slab surface finish tolerance and to compensate for metal deck deflection, beam camber and beam deflection.

4. Concrete Placement at Column Bays Supported on Transfer Girders or Trusses: Concrete in floor areas supported by transfer girders or trusses shall be placed and screeded to predetermined marks placed over the metal deck slab conforming to elevations as specified on the drawings. At least the minimum slab thickness, as specified on the drawings, shall be maintained throughout the slab surface. The Contractor shall conform to the F_F values specified above.

I. Remedial Measures for Slab Finish Construction Not Meeting Specified Tolerances:

1. Application of Remedial Measures. Remedial measures specified herein are required whenever either or both of the following occur:

   a. The composite overall values of F_F or F_L of the entire floor installation measure less than specified values.
   b. Any individual test section measures less than the specified absolute minimum F_F or F_L value.

2. Modification of Existing Surface:

   a. If, in the opinion of the Architect/Engineer or Owner's Representative, all or any portion of the substandard work can be repaired without sacrifice to the appearance or serviceability of the area, then the Contractor shall immediately undertake the approved repair method.
   b. The Contractor shall submit for review and approval a detailed work plan of the proposed repair showing areas to be repaired, method of repair and time to affect the repair.
   c. Repair method(s), at the sole discretion of the Architect/Engineer or Owner's Representative, may include grinding (floor stoning), planing, retopping with self leveling underlayment compound or repair topping, or any combination of the above.
   d. The Architect/Engineer or Owner's Representative maintains the right to require a test repair section using the approved method of repair for review and approval to demonstrate a satisfactory end product. If, in the opinion of the Architect/Engineer or Owner's Representative, the repair is not satisfactory an alternate method of repair shall be submitted or the defective area shall be replaced.

e. The judgment of the Architect/Engineer or Owner's Representative on the appropriateness of a repair method and its ability to achieve the desired end product shall be final.
f. All repair work shall be performed at no additional cost to the Owner and with no extension to the construction schedule.

3. Removal and Replacement:

a. If, in the opinion of the Architect/Engineer or Owner's Representative, all or any portion of the substandard work cannot be satisfactorily repaired without sacrifice to the appearance or serviceability of the area, then the Contractor shall immediately commence to remove and replace the defective work.
b. Replacement section boundaries shall be made to coincide with the test section boundaries as previously defined.
c. Sections requiring replacement shall be removed by sawcutting along the section boundary lines to provide a neat clean joint between new replacement floor and existing floor.
d. The new section shall be reinforced the same as the removed section and doweled into the existing floor as required by the Engineer. No existing removed reinforcing steel may be used. All reinforcing steel shall be new steel.
e. Replacement sections may be retested for compliance at the discretion of the Architect/Engineer or Owner's Representative.
f. The judgment of the Architect/Engineer or Owner's Representative on the need for replacement shall be final.
g. All replacement work shall be performed at no additional cost to the Owner and with no extension to the construction schedule.

3.9 CONCRETE CURING AND PROTECTION

A. General:

1. 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. Limit moisture loss to a maximum of 0.05 lb. /sq. ft – hr for concrete containing silica fume and 0.2 lb. /sq. ft. - hr for all other concrete before and during finishing operations.. If using an evaporation retarder, apply in accordance with manufacturer's instructions after screeding and bull floating, but before power floating and troweling.

2. 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.

Alternatively, curing times may be reduced if either of the following provisions is complied with:

a. If tests are made of cylinders kept adjacent to the structure and cured by the same methods, curing measures may be terminated when the average compressive strength has reached 70% of the specified 28 day compressive strength.
b. If the temperature of the concrete is maintained at a minimum of 50°F for the same length of time required for laboratory cured cylinders of the

same concrete to reach 85% of the 28 day compressive strength, then curing may be terminated thereafter.

3. Curing shall be in accordance with ACI 301 procedures. Avoid rapid drying at the end of the curing period.

B. Curing Formed Surfaces: Where wooden forms are used, cure formed concrete surfaces, including undersides of beams, supported slabs and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. When forms are removed, continue curing by one or a combination of the methods specified below, as applicable.

1. Columns and shearwalls that are not exposed to view: Moist cure in forms or by one or a combination of methods 1, 2, or 3 specified below. Use a high –solids, liquid membrane-forming curing and sealing compound conforming to ASTM C 1315, type I, Class A or B for method 3.

2. Columns and shearwalls that are exposed to view: Moist cure in forms or by one or a combination of methods 1, 2 or 3 specified below. Use a high-solids, non-yellowing, liquid membrane-forming curing and sealing compound conforming to ASTM C 1315, type 1, class A for method 3.

3. Sides and Soffits of Beams and Pan-Joist Ribs, Soffits of Slabs: Moist cure in forms or by one or a combination of methods 1, 2 or 3 specified below. Use a liquid membrane-forming dissipating resin curing compound conforming to ASTM C 309, type 1, class A or B for method 3.

4. Basement Walls, Sides of Exterior Retaining Walls: Moist cure in forms or by one or a combination of methods 1, 2 or 3 specified below. Use a liquid membrane-forming dissipating resin curing compound conforming to ASTM C 309, type 1, class A or B for method 3.

C. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, floor topping and other flat surfaces by one or a combination of the methods specified below, as applicable. The Contractor shall choose a curing method that is compatible with the requirements for subsequent material usage on the concrete surface.

1. Ramps and Horizontal Surfaces of Parking Areas, Exposed Exterior Balconies: Cure using only methods 1 or 2 as specified below.

2. Floors Directly Exposed to Vehicular or Foot Traffic not in Parking Areas and not otherwise receiving a chemical hardener or penetrating sealer finish: Apply two coats of a high-solids, water-based, non-yellowing, liquid membrane-forming curing and sealing compound conforming to ASTM C 1315, type 1, Class A in accordance with method 3 as specified below.

3. Floors in Non-Public spaces that are left exposed to view and not receiving sealers or hardeners, floors involved in under-floor air distribution systems: Apply one coat of a high-solids, water-based, non-yellowing, liquid membrane-forming curing and sealing compound conforming to ASTM C 1315, type 1, Class A or B in accordance with method 3 as specified below.

4. Floors that are to receive subsequent cementitious toppings, sealers, hardeners, ceramic tile, acrylic terrazzo, vinyl composition tile, sheet vinyl, linoleum, vinyl-backed carpet, rubber, athletic flooring, synthetic turf, wood, epoxy overlay or

adhesive, or other coating or finishing products: Cure using methods 2 or 3 as specified below. Use a water-based dissipating resin type curing compound conforming to ASTM C 309, type 1, class A or B for method 3.

5. Industrial Slabs: Cure using methods 1 or 2 as specified below for 7 days. The temperature of applied water shall be with 10° F of concrete surface temperature.

6. All Other Surfaces: Cure using methods 1, 2 or 3 as specified below. Use a water-based dissipating resin type curing compound conforming to ASTM C 309, type 1, class A or B for method 3.

D. Curing Methods:

1. Method 1 - Moisture Curing: 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 continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with 4" lap over adjacent absorptive covers.

2. Method 2 - Moisture-Retaining Cover Curing: Provide moisture-retaining cover curing as follows:

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. Water may be added to concrete surface to prevent drying before the cover is installed, but the surface shall not be flooded with water if a non-absorptive cover is used.

3. Method 3 – Curing or Curing and Sealing Compound: Provide curing, curing/hardener, liquid membrane-forming curing, or curing and sealing compound as follows:

Apply specified compound to concrete slabs as soon as final finishing operations are complete (within 2 hours and after surface water sheen has disappeared). Apply uniformly in continuous operation by power-spray or roller in accordance with manufacturer's directions. Do not allow to puddle. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period. Apply second coat for sealing 2 to 3 hours after the first coat was applied.

Do not use membrane-forming curing and sealing compounds on surfaces which 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, glued-down carpet, vinyl composition tile, linoleum, sheet vinyl, rubber, athletic flooring, synthetic turf, or wood), paint or other coatings and finish materials. Dissipating resin type cures are acceptable in these locations.

3.10 HOT WEATHER CONCRETING

A. Definition:

1. Conditions warranting hot weather concreting practices are defined as any combination of high air temperature, low relative humidity and wind velocity tending to impair the quality of fresh or hardened concrete or otherwise result in abnormal properties. If conditions cause an evaporation rate of 0.2 lb. /sq. ft. /hr. as calculated by Figure 2.1.5 in ACI 305R-99, then precautions shall be taken to prevent plastic shrinkage cracks from occurring.

B. Specification: Follow hot weather concreting practices specified below when required to limit the concrete temperature at the truck discharge point to the stated maximum acceptable temperature.

C. Records: Under hot weather conditions, the Contractor shall keep records of outside air temperature, concrete temperature at truck discharge and general weather conditions.

D. Hot Weather Concreting Requirements: The following items, all or in part as required, shall be followed to limit the concrete temperature to the stated maximum acceptable temperature and to minimize the possibility of plastic shrinkage cracks from developing.

1. Design the concrete mixes specifically for hot weather conditions replacing some cement with fly ash or other pozzolan and using a water reducing retarding admixture (ASTM C 494 Type D).

2. Use the largest size and amount of coarse aggregate compatible with the job.

3. Use sunshades and/or windbreaks.

4. Delay construction of indoor slabs-on-grade until the walls and roof are constructed.

5. Cool and shade aggregate stockpiles.

6. Use ice as part of the mixing water or cool the water with liquid nitrogen.

7. Limit the number of revolutions at mixing speed to 125 maximum.

8. Reduce time between mixing and placing as much as possible.

9. Do not add water to ready-mixed concrete at the job site unless it is part of the amount required initially for the specified water-cement ratio and the specified slump.

10. Schedule concrete placement for early morning, late afternoon, or night.

11. Have all forms, equipment and workers ready to receive and handle concrete.

12. Maintain one standby vibrator for every three vibrators used.

13. Keep all equipment and material cool by spraying with water including exteriors of forms, reinforcing steel, subgrade, chutes, conveyors, pump lines, tremies, and buggies.

14. Protect slab concrete at all stages against undue evaporation by applying a fog spray or mist above the surface or applying a monomolecular film. Where high temperatures and/or placing conditions dictate, use water-reducing retarding

admixture (Type D) in lieu of the water-reducing admixture (Type A) as directed by the Owner's Testing Laboratory.

15. Provide continuous curing, preferably with water, during the first 24 hours using wet burlap, cotton mats, continuous spray mist, or by applying a curing compound meeting ASTM C 1315. Continue curing for 3 days minimum.

16. Cover reinforcing steel with water soaked burlap so that steel temperature will not exceed ambient air temperature immediately before placement of concrete.

17. As soon as possible, loosen forms and run water down the inside. When forms are removed, provide a wet cover to newly exposed surfaces.

3.11 COLD WEATHER CONCRETING

A. Definition:

1. Concrete shall not be placed when the outside air temperature is 40°F or less unless cold weather concreting practices are followed as specified below.

2. Cold weather concreting practices should also be followed whenever the average daily air temperature is expected to be less than 40°F for more than three successive days. The average daily air temperature is the average of the highest and lowest temperature occurring during the period from midnight to midnight. The requirement for adhering to these cold-weather concreting practices may be terminated when the air temperature is above 50º F for more than half of any 24 hour duration.

3. Cold-weather concreting practices invoked shall keep the temperature of the concrete immediately after placing within the following temperature ranges:

   a. 55º to 75º F for sections less than 12 in. in the least dimension
   b. 50º to 70º F for sections 12 to 36 in. in the least dimension
   c. 45º to 65º F for sections 36 to 72 in. in the least dimension
   d. 40º to 60º F for sections greater than 72 in. in the least dimension

4. Concrete Protection: Protect the concrete immediately after placing and during the defined protection period such that the concrete does not freeze nor fall below the temperature levels stated in the above paragraph. For concrete not loaded during construction the protection period shall be for a minimum of three days if cold-weather conditions persist. The time period may be reduced to a minimum of two days if Type III cement or an accelerating admixture is used or if an additional 100 pounds of cement per cubic yard is added to the concrete mix. Concrete fully loaded during construction shall be protected during cold weather conditions for whatever time period is required to obtain the required strength as determined by nondestructive strength tests (Windsor probe, Swiss Hammer Test) on the in-place concrete. Protect concrete surfaces from freezing for the first 24 hours even if cold-weather conditions do not officially exist due to high volatility in ambient temperatures.

5. Protection Deficiency: If the temperature requirements during any portion of the protection period are not met but the concrete surface did not freeze, the protection period shall be extended until twice the deficiency expressed in degree-hours is made up. Deficiency degree-hours are defined as the average deficiency in temperature below the required value times the number of hours the

deficiency persisted. Make-up degree hours are the average increase in temperature above the minimum value times the hours required to make up twice the deficiency degree-hours. Contact the Architect/Engineer if the concrete surface was allowed to freeze during the protection period.

6. Protection Removal: As the protection is being removed the decrease in temperature measured at the surface of the concrete in a 24 hour period shall not exceed the following:

   a. 50° F for sections less than 12 in. in the least dimension
   b. 40° F for sections 12 to 36 in. in the least dimension
   c. 30° F for sections 36 to 72 in. in the least dimension
   d. 20° F for sections greater than 72 in. in the least dimension

7. The maximum concrete temperature heated by artificial means at point of placement shall not exceed 90°F.

B. Records: Under cold weather conditions, the Contractor shall keep records of outside air temperature, concrete temperature as placed and general weather conditions. The temperature record shall be taken no less than 2 times per 24 hour duration.

C. Cold Weather Concreting Requirements: The following items, all or in part as required, should be followed to assure acceptable concrete in cold weather conditions:

1. Design the concrete mix to obtain high early strength by using higher cement content, a high early strength cement (Type III), or a specified non-chloride accelerator (ASTM C 494 Type C or E).

2. Protect the concrete during curing period using insulating blankets, insulated forms, enclosures and/or heaters.

3. Concrete cured in heated enclosures shall have heaters vented to prevent exposure of concrete and workmen to noxious gases.

4. Frozen subgrade shall be thawed prior to concrete placement and snow and ice shall be removed from forms.

5. Temperature of embedments in concrete must be heated to above 32° F prior to placing concrete

6. Heat the mixing water and then blend hot and cold water to obtain concrete no more than 10°F above the required temperature.

7. Heat the aggregates by circulating steam in pipes placed in the storage bins for air temperatures consistently below 32°F. When either water or aggregate is heated to over 140°F combine them in the mixer first to obtain a maximum temperature of the mixture not to exceed 140°F in order to prevent flash set of the concrete.

8. Uniformly thaw aggregates far in advance of batching to prevent moisture variations in the stockpile.

9. Cover warmed stockpiles with tarps to retain heat.

10. Place air entraining admixture in the batch after the water temperature has been reduced by mixing with cooler solid materials.

11. Use wind screens to protect concrete from rapid cooling.

12. Place vertical pump lines inside the building, if possible, for concrete being pumped.

13. Maintain artificial heat as low as possible to reduce temperature stresses during cooling.

14. Avoid water curing of concrete except for parking garage structures. Apply the required curing compound to unformed surfaces as soon as possible to prevent drying of concrete from heated enclosures.

15. Delay form stripping as long as possible to help prevent drying from heated enclosures and to reduce damage to formed surfaces caused by premature stripping.

16. Provide triple thickness of insulating materials at corners and edges vulnerable to freezing.

17. Wrap protruding reinforcing bars with insulation to avoid heat drain from the warm concrete.

18. Gradually reduce the heat at the end of the heating period to reduce likelihood of thermal shock.

3.12 MISCELLANEOUS CONCRETE ITEMS

A. 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.

B. 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.

C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations, as shown on drawings. Set anchor rods for machines and equipment to template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.

D. Grout base plates and foundations as indicated, using specified non-shrink, non-metallic grout. Use high-flow grout where high fluidity and/or increased placing time are required. This grout shall be used for all base plates larger than 10 square feet.

E. Steel Pan Stairs: Provide concrete fill for steel pan stair treads and landings and associated items. Cast-in safety inserts and accessories as shown on drawings. Screed, tamp and finish concrete surfaces as scheduled.

F. Installation of adhesive anchors using injectable epoxy or adhesive: A representative of the adhesive manufacturer shall be present for the first day that adhesive anchors are installed. After drilling the hole to the diameter and depth recommended by the

manufacturer, clean the hole with a wire or nylon brush. Blow the dust out of the hole using compressed air with a nozzle that reaches to the bottom of the hole. When using adhesive from a new pack, the adhesive that is discharged from the mixing nozzle should be a uniform gray color before any adhesive is installed in the hole. Fill the hole with adhesive starting from the very bottom of the hole until the hole is about 2/3 full. Do not leave an air pocket at the bottom of the hole. Insert the anchor rod or dowel by slowly twisting it into the hole.

3.13 CONCRETE SURFACE REPAIRS

A. Definition - Defective Areas:

1. Formed Surfaces: Concrete surfaces requiring repairs shall include all cracks in excess of 0.01" and any other defects that affect the durability or structural integrity of the concrete. Voids, including honeycombing and rock pockets, and tie holes shall be repaired as required by the specified Surface Finish.

2. Unformed Surfaces: Concrete surfaces requiring repair shall include all surface defects such as crazing, cracks in excess of 0.01" wide or cracks which penetrate to reinforcement or through the member, popouts, spalling and honeycombs.

B. Classification:

1. Structural Concrete Repair: Major defective areas in concrete members that are load carrying (such as shear walls, beams, joists and slabs), are highly stressed, and are vital to the structural integrity of the structure shall require structural repairs. Structural concrete repairs shall be made using a two-part epoxy bonder, epoxy mortar or specified polymer repair mortar. The Engineer shall determine the locations of required structural concrete repairs.

2. Cosmetic Concrete Repair: Defective areas in concrete members that are non-load carrying and minor defective areas in load carrying concrete members shall require cosmetic concrete repair when exposed to view and not covered up by architectural finishes. Cosmetic concrete repairs may be made using a polymer repair mortar and compatible bonding agent. The Architect/Engineer shall determine the locations of required cosmetic concrete repairs. Stains and other discolorations that cannot be removed by cleaning and are exposed to view will require cosmetic repair. Cosmetic concrete repair in exposed-to-view surfaces will require Architect's approval prior to patching operation.

3. Slab Repairs: High and low areas in concrete slabs shall be repaired by removing and replacing defective slab areas unless an alternate method, such as grinding and/or filling with self-leveling underlayment compound or repair mortar is approved by the Architect/Engineer. Repair of slab spalls and other surface defects shall be made using epoxy products as specified above and as determined by the Engineer. The high strength flowing repair mortar may be used for areas greater than 1 inch in depth.

3.14 QUALITY ASSURANCE TESTING AND INSPECTION DURING CONSTRUCTION

A. See Testing Laboratory Services section of these Specifications for concrete materials and cast-in-place concrete inspection and test requirements.

END OF SECTION 03 30 00

Date: _____

Concrete Mix Design
Submittal Form (Note 1)

I. Project Information
- A. Name of Project: _____ B. City, State: _____
- C. General Contractor: _____
- D. Concrete Supplier: _____
  - 1. Address: _____
  - 2. Name to Contact: _____ 3. Phone No.: _____ 4. Fax No.: _____

II. Concrete Mix Information
- A. Concrete Mix Design Designation (Note 2): _____
- B. Minimum Concrete Strength f'c: _____ psi at _____ days and C. Maximum w/c Ratio:_____
- D. Concrete Type (check one) _____NW _____LW E. Required Wet Weight: _____pcf
- F. Concrete Use (member type as specified in General Notes): _____
- G. Required Air Content: _____%
- H. Method of Concrete Placement for this Mix:
  (check one) ____ Bucket ____ Pump ____ Chute ____ Tremie ____ Other (Specify) _____

III. Method of Concrete Mix Design Preparation: (Check One Method Below) (Note 3)
- A. _____ Field Experience Method B. _____ Trial Mixture Method

IV. Concrete Production Facility Information
- A. Production facility has field strength test records of specified class or within 1 ksi of class: ____ Yes ____ No
  Answer B thru C only if answer to IV.A. is "yes". If answer to IV.A. is "no", go to V.B.:
- B. Test Record Information: (Check either 1, 2, or 3 below)
  1. _____ ≥ 30 consecutive tests 2. _____ Two groups of ≥ 30 tests 3. _____ 15 to 29 tests
- C. Standard Deviation S(PSI):
  1. Modification Factor (if B.3. checked only. Ref. Table 5.3.1.2 of ACI 318-02.) MF = _____
  2. Standard Deviation S = _____ psi 3. MF x S (if B.3. checked only) = _____ psi

Note: Combined aggregate gradation for slabs and other designated concrete shall be 8% -18% for large top size aggregates (1 ½ in.) or 8%-22% for smaller top size aggregates (1 in. of ¾ in.) retained on each sieve below the top size and above the No. 100 sieve.

V. Required Average Compressive Strength f'cr (psi)
- A. Calculation of f'cr from S (fill out only if IV.A. is "yes") (larger of 1 or 2 below controls)
  1. f'cr = f'c + 1.34 x S = _____ psi 2. f'cr = f'c + 2.33 x S - 500 = _____ psi
- B. Calculation of f'cr from ACI 318-02 Table 5.3.2.2: (fill out if IV.A. is "No")
  1. f'cr = f'c + _____ psi = _____ psi

VI. Concrete Mix Design by Field Experience Method: (fill out below only if III.A. is checked)
Note: This method requires one or more mix designs with a 45 day minimum field record of at least ten consecutive test results using similar materials and conditions as the proposed mix design.
- A. Available field record is based on how many mix designs? _____ (specify number)
- B. Average strength of field record is _____ psi (must be ≥ f'cr in V.)

VII. Concrete Mix Design by Trial Mixture Method: (fill out below only if III.B. is checked)
Note: This method requires using at least three different trial mixes with varying W/C ratios or cement contents with a plot of average strength vs. W/C ratio or cement content. Submit scale graph of results.
- A. Trial Mixes: (Note: All other ingredients as specified in VIII. below)

	Mix 1	Mix 2	Mix 3	Selected (interpolated) values
Cements (lbs.)	_____	_____	_____	_____
W/C Ratio	_____	_____	_____	_____
Compressive Strength (psi) at Specified Days	_____	_____	_____	_____

VIII. Proposed Mix Design
- A. Sources of Materials:
  1. Cement: Type: ____ Manufacturer _____Lo-Alkali? Y N Sp. Gr._____
  2. Fly Ash: Type: ____ Manufacturer _____ Sp. Gr._____
  3. Silica Fume: Manufacturer: _____ Type (check one): ___ Slurry ___ Powder
     Slurry: Specific Gravity _____ Water Content by Wt. _____% Silica by Wt. _____%
     Powder: Specific Gravity _____ Silica by Wt. _____%
  4. Coarse Aggregate: Size: _____ Type: _____ Source: _____ Ovendry Sp. Gr._____
     (Note 4) Ovendry Rodded Density: _____ PCF Absorption: _____% (moist. content at SSD cond.)

5. Lightweight Agg.:_____ Size: _____ Type: _____ Source: _____ Ovendry Sp. Gr. (Note 4) Ovendry Rodded Density: _____ PCF Absorption: ____% (moist. content at SSD cond.)
6. Fine Aggregate: Type: _____ Source: _____ Fineness Modulus: _____ (Note 4) Ovendry Sp. Gr. _____ Absorption (moisture content at SSD condition): ____%
7. Air Entraining Agent (AEA): Manufacturer and Name: _____ ASTM No. _____

Note: Specify below all types and combinations of admixtures anticipated to be used for all anticipated weather conditions. Explain in (12) below.

8. Water Reducers (WR):
   a. (Plain) Manufacturer and Name: _____ ASTM No._____
   b. (w/Accelerator) Manufacturer and Name: _____ ASTM No._____
   c. (w/Retarder) Manufacturer and Name: _____ ASTM No._____
9. Accelerators: Manufacturer and Name: _____ ASTM No._____
10. Retarders: Manufacturer and Name: _____ ASTM No._____
11. High Range Water Reducer (HRWR) (superplasticizers):
    a. (Plain) Manufacturer and Name: _____ ASTM No._____
    b. (w/Retarder) Manufacturer and Name: _____ ASTM No._____
12. Comments: _____

B. Mix Proportions: (Per Cubic Yard)

Item	Wt. (lbs.)	Absolute Vol. (Cu. Ft.)	
1. Cement	_____	_____	
2. Fly Ash	_____	_____	
3. Silica Fume	_____	_____	
4. Coarse Agg. (SSD Wt.)	_____	_____	
5. Lightweight Agg. (SSD Wt.)	_____	_____	
6. Fine Agg. (SSD Wt.)	_____	_____	
7. AEA	_____ oz/100# cement	Added at: ___ Batch Plant ___ Site	
8. a. WR (Plain)	_____ oz/100# cement	Added at: ___ Batch Plant ___ Site	
b. WR (W/Acc.)	_____ oz/100# cement	Added at: ___ Batch Plant ___ Site	
c. WR (W/Ret.)	_____ oz/100# cement	Added at: ___ Batch Plant ___ Site	
9. Accelerator:	_____ oz/100# cement	Added at: ___ Batch Plant ___ Site	
10. Retarder:	_____ oz/100# cement	Added at: ___ Batch Plant ___ Site	
11. a. HRWR (Plain)	_____ oz/100# cement	Added at: ___ Batch Plant ___ Site	
b. HRWR (w/Ret.)	_____ oz/100# cement	Added at: ___ Batch Plant ___ Site	
12. Other: _____ (Specify Units)			
13. Water (including free water on aggregates)	_____ (lbs.)	_____ (cu. ft.)	_____ (gal.)

C. Mix Design Characteristics: (Pozzolan = flyash and/or silica fume)
1. Water (including free water on aggregates)/(Cement + pozzolan): W / C = $\frac{\text{(lbs.)}}{\text{(lbs.)}}$ = _____ (Not applicable for LW concrete)
2. Fine Aggregate/Total Aggregate = $\frac{\text{(lbs.)}}{\text{(lbs.)}}$ = _____ 3. Pozzolan/Pozzolan+Cement) = $\frac{\text{(lbs.)}}{\text{(lbs.)}}$ = _____
4. Concrete Density: a. Unit Wet Weight: _____ pcf b. Unit Dry Weight: _____ pcf
5. Air Content: _____%
6. Slump or Slump Flow a. Initial Slump (before adding WR or HRWR) _____ in.
   b. Final Slump or Flow (after adding WR or HRWR or SCC) _____ in.

D. Chloride Ion Content: The Concrete Supplier certifies that total chloride ion content of the concrete mix, as tested by ASTM C 1218 does not exceed the amounts specified in Table 4.4.1 of ACI 318.

E. Alkali Content: The Concrete Supplier certifies, if required by specification section 3300, that the total alkali content contributed from cementitious materials does not exceed 4.0 lbs./cu. yd. of concrete or certifies that the aggregate contains no deleterious material that react with alkalis in the concrete mix.

F. Mix Water Purity: The Concrete Supplier certifies that the appropriate specified chemical concentration limits are not exceeded in the total volume of mix water.

Notes:

1. This form is required to be submitted to Engineer and Owner's Testing Laboratory for all concrete mixes on the job. When any mix ingredient changes during the course of the job, this submittal form shall be resubmitted for approval. All information must be filled in for approval of mix design. Submit all backup data for calculations.
2. The mix designation should be that used by the Contractor to order the concrete from the Supplier and as noted on the batch ticket.
3. Refer to ACI 318 for requirements of each concrete mix design preparation method.
4. Submit sieve analysis of fine and course aggregates. Include chart indicating combined aggregate retained on each sieve size.

X. Certification by Concrete Supplier

Signature: _____ Representing: _____ Date:_____

SECTION 03 31 00 – EPOXY RELATED WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of contract, including General and Supplementary Conditions and Division - 01 Specification Sections, apply to the work of this section.

1.2 SCOPE OF WORK

A. The following epoxy related work is shown on the drawings and in this project manual:

1. Crack locations and approximate lengths of cracks for epoxy injection work.

2. Epoxy mortar patch locations and approximate sizes.

3. Polymer mortar patch locations and approximate sizes.

4. Locations requiring epoxy bonder between fresh and hardened concrete.

5. Locations requiring bolts, dowels or reinforcing steel set in epoxy.

6. Locations requiring skid-resistant surface on concrete by the use of multi-component epoxy or non-epoxy systems.

7. Locations requiring epoxy penetrant sealer.

8. Locations requiring self-penetrating concrete crack filler and sealer using high molecular weight methacrylates.

9. Locations requiring polymer modified cementitious mortar overlay system.

10. Locations requiring epoxy resin overlay system.

These drawings are for the Contractor's guidance only, and are to be considered as a minimum for pricing. Contractor shall not do any additional work beyond what is shown in the drawings without prior written approval of the Architect/Engineer.

B. Contractor shall fully acquaint himself with the existing job site conditions and discuss the accessibility of the work areas with the Owner.

C. Contractor shall ensure that there is adequate ventilation in areas where epoxy repair work is being performed and that no work results in nauseating, annoying or toxic fumes and odors from entering occupied areas. Provide barricades around the work area with appropriate signage to keep non-construction people from entering work area.

D. Contractor shall provide all traffic cones or barriers to direct traffic during the repair of the parking garage. This work shall be done in consultation with the Owner.

E. During the course of construction, Architect/Engineer may require certain items to be repaired by methods involving epoxies. Repairs may include epoxy injection of cracks, epoxy or polymer mortar patching, epoxy grouted dowels or reinforcing steel, and

bonding fresh concrete to hardened concrete. Such work shall be done by the Contractor in strict conformance to these specifications.

1.3 QUALITY ASSURANCE

A. Applicable Standards – most recent version

1. American Society for Testing and Materials (ASTM)

C881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

2. American Concrete Institute (ACI)

ACI 503 R	Use of Epoxy Compounds with Concrete
ACI 503.1	Standard Specification for Bonding, Hardened Concrete, Steel, Wood, Brick, and Other Materials to Hardened Concrete with a Multi-Component Epoxy Adhesive
ACI 503.2	Standard Specification for Bonding Plastic Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive
ACI 503.3	Standard Specification for Producing a Skid-Resistant Surface on Concrete by the Use of Multi-Component Epoxy System
ACI 503.4	Standard Specification for Repairing Concrete with Epoxy Mortars
ACI 548.1R	Guide For Use of Polymers in Concrete

B. Manufacturer's Qualifications: Companies furnishing the epoxy materials shall have a proven track record of at least five years. Furthermore, they shall have in existence a program of training, certifying and supporting a nationally organized program of approved contractors. Evidence of this shall be made available to the Engineer/Architect upon request.

C. Contractor's Qualifications: Contractor performing the work shall be an approved contractor by the manufacturer furnishing the epoxy materials, and shall have no less than five years experience in the various types of epoxy related work required in this project. A notarized certification from the manufacturer attesting to the training shall be submitted to the Engineer/Architect along with the proposal to do the work.

D. Injection Equipment Requirements: Injection equipment used by the Contractor shall be from a manufacturer who has been producing such equipment for a minimum of five years. Such equipment shall have a record of satisfactorily proportioning, mixing, and dispensing of the injection resin being used.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR EPOXY MATERIALS

A. All epoxy material shall be new and manufactured within the shelf life limitations set forth by the manufacturer.

B. Epoxy shall be a two-part epoxy adhesive material, and shall be of epichlorohydrin/amine type. Polysulphide epoxies are not acceptable.

C. Epoxy used shall be insensitive to the presence of water and moisture, and shall be capable of application and of strength development even when applied to damp surfaces having a temperature of 40° or above.

D. Epoxy used shall develop a minimum strength of 2000 psi in tension and 4000 psi in compression at the end of seven days.

E. Epoxies used shall not deteriorate under approximately 200 freeze thaw cycles.

F. Epoxies used shall be 100% solids without solvents.

G. With the exception of epoxy penetrant sealers, epoxies used shall be 100% solids without solvents.

H. Bonding and strength characteristics of epoxies shall be stable when exposed to ultraviolet rays.

I. The viscosity of the epoxy used for injection work shall be low enough (about 300 cps at 77°F) to completely fill hairline cracks as small as 10 mils.

2.2 ADDITIONAL REQUIREMENTS FOR EPOXY MORTARS

A. Epoxy mortar used for bonding, patching, and resurfacing, shall have the following additional properties:

1. Epoxy mortar shall be non-sagging.

2. Sand used in preparing mortar shall be graded oven dry quartzite and furnished in bags.

3. The epoxy mortar patch material shall match the existing texture and color of exposed concrete without giving a blotchy appearance. A test patch shall be applied for approval prior to final acceptance of the mortar. Size of test patch shall be approximately equal to the size of the average mortar patch to be used on the project.

2.3 GENERAL REQUIREMENTS FOR POLYMER MODIFIED CEMENTITIOUS MORTARS

A. Mortar used for bonding, patching, and resurfacing in exposed or exterior environmental conditions with large cyclic temperature changes shall have the following properties:

1. Mortar shall be non-sagging.

2. Coefficient of thermal expansion shall be comparable with that of concrete (5.5 x 10^{-6} in/in/°F).

3. Sand used in preparing mortar shall be graded oven dry quartzite furnished in bags.

4. The mortar patch material shall match the existing texture and color of exposed concrete without giving a blotchy appearance. A test patch shall be applied for approval prior to final acceptance of the mortar. Size of test patch shall be approximately equal to the size of the average mortar patch to be used on the project.

2.4 GENERAL REQUIREMENTS FOR HIGH MOLECULAR WEIGHT METHACRYLATE SELF-PENETRATING CONCRETE CRACK FILLER AND SEALER

A. Crack filler used shall be a synthesized methacrylate monomer having high molecular weight, low viscosity and low volatility with the following properties.

1. Viscosity shall be between 15 and 30 cps Brookfield LVT W/UL adapter 50 RPM at 77°F.

2. Density shall be a minimum of 8.5 pounds per gallon at 77°F.

3. Material shall not gel under 16 hours exposure to 205°F temperature.

4. Odor should be barely perceptible.

5. Material shall cure in less than 8 hours at 75° temperature when applied to a surface.

6. Resin used shall be free of wax additives.

2.5 PRODUCTS AND MANUFACTURERS

A. Epoxy Injection Work

1. Masterinject 1380.

2. E-Poxy Industries: Eva-Pox Injection Resin No. 4.

3. Rescon Technology Corp.: Product R303, Concrete Injection Resin.

4. Sika Chemical Corporation: Sikadur Hi-Mod LV or Sikadur 52 Injection Resin.

5. Thermal-Chem, Inc.: Thermal-Chem Injection Resin, Product No. 2.

B. Epoxy Mortar Patch

1. Master Builders Technologies: Concresive 1411 or 1482.

2. E-Poxy Industries: Eva-Pox Mortar Mix No. 3.

3. Rescon Technology Corp.: Product No. R616, Concrete Bonder or Product No. R404, Epoxy Mortar Resin.

4. Sika Chemical Corporation: Sikadur 31 Hi-Mod Gel or Sikadur 35 Hi-Mod LV.

5. Thermal-Chem, Inc.: Thermal-Chem Mortar Resin Product No. 3, Thermal-Chem Fibrous Mortar Resin, Product No. 306 or Thermal-Chem Mortar Resin Gel, Product No. 304.

C. Epoxy for Bonding Steel Plates

1. Master Builders Technologies: Concresive 1440, 1441, or 1442.
2. E-Poxy Industries: Eva-Pox Bonder No. 1 or Eva-Pox Cold Cure Bonder No. 41.
3. Rescon Technology Corp.: Product R626, Concrete Bonder.
4. Sika Chemical Corporation: Sikadur 31 Hi-Mod Gel.
5. Thermal-Chem, Inc.: Thermal-Chem Bonder, Product No. 4, Normal Cure or Rapid Cure.

D. Epoxy for Bonding Fresh Concrete to Hardened Concrete

1. Master Builders Technologies: Concresive Liquid (LPL) or Concresive 3007.
2. E-Poxy Industries: Eva-Pox Fresh Concrete Bonder No. 2.
3. Rescon Technology Corp.: Product R649, Fresh Concrete Bonder.
4. Sika Chemical Corporation: Sikadur 32 Hi-Mod.
5. Thermal-Chem, Inc.: Thermal-Chem Wet Concrete Bonder, Product No. 5 or 501.

E. Epoxy for Grouting Bolts, Dowels or Reinforcing Steel

1. Master Builder Technologies: Concresive Liquid (LPL), Concresive 3007, Concresive Paste (LPL) for horizontal use in conditioned spaces.
2. E-Poxy Industries: Eva-Pox Cold Cure Bonder No. 41.
3. Rescon Technology Corp.: Product No. R606, Concrete Bonder.
4. Sika Corporation: Sikadur 31 Hi-Mod Gel, (horizontal and overhead use); Sikadur 32 Hi-Mod or Sikadur 35 Hi-Mod LV (vertical downhand use).
5. Thermal-Chem, Inc.: Thermal-Chem Bonder, Product No. 4, Normal Cure or Rapid Cure.

F. Epoxy for Skid-Resistant Surface

1. Master Builders Technologies: Concresive 1064.
2. E-Poxy Industries: Eva-Pox Product No. 730 or 735.
3. Rescon Technology Corp.: Product R505, Industrial & Hi-Traffic Coating.
4. Sika Chemical Corporation: Sikadur 22, Lo-Mod.
5. Thermal Chem, Inc.: Thermal-Chem Ramp and Floor Coating, Product No. 7, System No. 7-02.

G. Epoxy Penetrant Sealer

1. Adhesive Engineering Company: Pen Seal 25.

2. E-Poxy Industries: Eva-Pox Perm Seal 50.

3. Rescon Technology Corp.: Product R117, Penetrant Sealer.

4. Sika Chemical Corporation: Sikagard 619.

5. Thermal-Chem, Inc.: Thermal-Chem Penetrating Sealer, Product No. 1-15.

H. Polymer Modified Cementitious Mortar Patch

1. Master Builders Technologies: Masterpatch 210, Masterpatch 220, or Masterpatch 230 VP.

2. Rescon Technology Corp.: Polymer Concrete, Product No. R424.

3. Sika Chemical Corporation: Sikatop 122, or Sikatop 123.

I. Polymer Modified Cementitious Mortar Overlay System

1. Sika Chemical Corporation: Sikatop 122 Repair Mortar or Sikatop 111 Self-Leveling Mortar.

J. Epoxy Resin Floor Overlay System

1. Sika Chemical Corporation: Sikafloor 90N.

K. High Molecular Weight Methacrylate Self-Penetrating Concrete Crack Filler

1. Sika Chemical Corporation: Sika Pronto 19, Crack Healer/Penetrating Sealer.

L. Corrosion Protection of Reinforcing Steel

1. Sika Chemical Corporation: Armatec 110.

2. ZRC Chemical Products Company: ZRC Cold Galvanizing Compound.

3. Rustoleum Zinc.

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

Changes in products required to suit temperature and environmental conditions at the time of material application shall be specified as separate line items by the Contractor showing credit or additions to the price for the various tasks.

In using the above products, follow strictly the manufacturer's specifications and directions for mixing and application. Also heed all label warnings by manufacturer. Make application in accordance with applicable safety laws.

2.6 CORROSION INHIBITING PAINT

A. Z.R.C. Cold Galvanizing Compound manufactured by ZRC Chemical Products Company, Quincy, Massachusetts.

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

2.7 SAND

A. Sand used for spreading over a surface application of the self-penetrating concrete crack filler and sealer using high molecular weight methacrylate shall be clean, washed, and dried silica sand free from all dust, dirt and organic materials.

1. Free moisture content of the sand shall be limited to a maximum of 0.25% by weight at time of application.

2. Sand used shall be oven-dried 20-40 graded quartz sand.

3. Sand used shall be uniformly graded with 100% passing the No. 10 sieve and retained on the No. 20 sieve.

4. Contractor shall submit samples of the sand to the Owner's Testing Laboratory for acceptance testing prior to commencing work. Do not change the source of material once the material source has been found to be acceptable.

2.8 JOINT FILLER MATERIAL

A. Filler material shall have a minimum Shore A hardness of 80, or Shore D hardness of 50, and shall conform to ASTM D2240-00.

1. Metzger/McGuire Co.: MM-80.

2. Sika Chemical Corporation: Sikadur 51 NS/SL.

B. Filler material shall have a minimum Shore A hardness of 35 and shall conform to ASTM D2240-00.

1. Tremco: Vulkem 245.

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

PART 3 - EXECUTION

3.1 EPOXY INJECTION

A. Applicator's Qualifications

1. Epoxy injection work shall only be performed by contractors who have successfully used this process on at least five similar structural repairs of 1000 linear feet or longer, and which have performed successfully for a minimum period of five years.

2. Only adequately trained epoxy injection applicators shall be used on the job. Furnish certificate of training prior to commencing work.

B. Preparation

1. Before proceeding, the space in the vicinity of the crack location receiving epoxy shall be swept and be in a generally clean condition to permit proper bonding of surface seal.

2. Cracks may be dry or damp, but free of standing water and frost.

3. Entry points shall be established judiciously at a distance along the seal so that epoxy penetrates the crack completely. Spacing of entry points, however, shall be no greater than the thickness of the concrete at that location. Tighter joints will require closer spacing of entry ports.

4. Adequate surface seal shall be applied to the face of the crack between the entry points. Use masking tape at the pre-established entry points to prevent the surface sealer from sealing the entry points. Alternatively, drill and port method may be used to establish entry points. Use only rotary-percussion type drills for drilling holes. Drills shall be fitted with bits having single tooth that produce large cuttings, and hollow stem drill rods that permit simultaneous blowing of compressed air providing immediate expulsion of the cuttings from the hole. Ensure that the drilling operation does not contaminate the cracks.

5. For through cracks, surface seal shall be applied to both faces. Provide entry ports on both faces staggered with each other when the cracked concrete element is greater than 8" thick. Injection of cracks from both faces shall also be necessary when the cracks are contaminated in concrete elements equal to or less than 8" thick.

6. Pre-sealing between ports may be done using a material meeting the requirements of these specifications.

7. Allow adequate time for the surface seal material to cure before proceeding with the injection.

C. Equipment for Injection

1. Pumps used for injection shall be a positive displacement type with interlock to provide positive ratio control in proper proportions. The pumps used shall be electrically or air powered, portable and shall provide an in-line mixing and metering system for the two-component epoxy. The pressure hoses and injection nozzle shall be of such a design as to allow proper mixing of the two components of the epoxy. Dwell time in mixing head shall not exceed ten seconds.

2. The injection equipment shall have automatic pressure control, and shall be capable of injection pressures up to 300 psi to ensure complete penetration of cracks. Equipment used shall also have the capability of presetting the pressures, and shall be equipped with manual pressure control override.

3. The presence of a stand-by injection unit shall be required.

D. Crack Cleaning

1. All cracks shall be cleaned and flushed with water, and checked for port-to-port transmission.

2. All cracks shall be cleaned and flushed with water, checked for port-to-port transmission. Cracks which are contaminated with algae shall be flushed with chlorinated water mixed with copper sulphate.

3. Blow the water out of the cracks using compressed air, and allow adequate time for drying before injecting with epoxy.

4. If in the process of water flushing the cracks, the Contractor notices rust particles being flushed out with the water, or if the water has rust stains, the Engineer shall be notified prior to doing any epoxy injection work. The Engineer will then evaluate the extent of corrosion in the embedded reinforcement, and make necessary adjustments in the repair procedure. The Engineer/Owner reserves the right to either issue a change order for any additional work involved or to delete those portions of the work which show evidence of corrosion of the reinforcing steel. When work is deleted, the Contractor shall give a credit to the Owner on the basis of unit prices quoted for the project.

5. When temperature is near the freezing point of water, ensure that the crack is free of ice before doing the injection work.

E. Epoxy Injection

1. Condition epoxy materials at temperature between 65°F-80°F unless otherwise recommended by the manufacturer. Epoxies beyond this range of temperature shall not be used. Do not store epoxy (even for a short period) in direct sunlight.

2. Epoxy adhesive shall be injected into the crack at the first lower entry port with sufficient pressure to advance the epoxy to the next adjacent port. The original port shall be sealed and entry shifted to the port in which the epoxy appears. This manner of port-to-port injection shall be continued until each joint has been injected for the entire length.

3. If port-to-port travel of epoxy is not achieved, the crack shall be identified, and the Architect/Engineer notified.

4. Samples of mixed material shall be injected into a paper cup every 60 minutes to test ratio mix. These samples shall be dated and numbered and left at the sampling location until reviewed by the testing laboratory.

5. Solvents shall not be used to thin epoxy introduced into the cracks.

F. Test Cores

1. A minimum of one test core shall be taken by the Testing Laboratory for every 100 feet of epoxy injection work. The total number of test cores taken shall not be less than three.

2. Cores shall be 2" to 4" in diameter, taken from locations marked by the Engineer. Before taking the cores from those locations, the Contractor shall use a magnetic reinforcing bar locator or employ other procedures to ensure that the core will not cut through any reinforcing steel. Should it be determined by the Contractor that the core location marked by the Engineer will cut through the reinforcing steel or prestressing tendons, the Contractor shall notify the Engineer for selecting alternate locations.

3. The cores shall be visually inspected for penetration of epoxy in the cracks. If the penetration is less than 95%, the repair work shall be considered unsatisfactory and unacceptable.

4. In addition to the visual inspection, one third of the cores or a minimum of three cores shall be tested under compression by an independent testing laboratory employed by the Owner. The epoxy injection work shall be considered acceptable if the concrete fails prior to adhesive failure.

5. If cores indicate either lack of penetration or deficiency in bond strength under compression test, the Contractor shall re-inject or perform other remedial work acceptable to the Architect/Engineer. Engineer then reserves the right to specify and request additional core samples for inspection and compression test by the testing laboratory, the cost of which shall be borne entirely by the Contractor.

6. All test cores shall be filled completely with polymer mortar to match color, finish, and texture of existing concrete. Mortar used shall comply with the requirements of these specifications.

G. Finishing

1. Allow epoxy adhesive in the cracks to cure before removing the surface seal. Ensure that there is no drainage of epoxy from the cracks due to premature removal of surface seal.

2. The surface of the crack herein treated shall be finished flush with the adjacent concrete surfaces and shall show no indentations or evidence of port fittings.

3. All work shall be performed and conducted in a neat, orderly manner. Clean-up whatever portions of the existing structure that get soiled or stained in the process of epoxy injection work.

3.2 EPOXY MORTAR

A. Applicator's Qualifications

1. Epoxy mortar repair work shall only be performed by contractors who have successfully used this process on at least three similar structural repairs of equal scope which have performed successfully for a minimum period of five years.

2. Only adequately trained and experienced personnel shall be used on the job.

B. Surface Preparation

1. Concrete surface to which the epoxy mortar is to be applied shall be exposed parent concrete free of loose and unsound materials. Surface preparation shall be done by abrasive blasting, waterblasting or as otherwise required by the manufacturer.

2. Necessary approvals shall be obtained by the Contractor from authorizing governmental or other agencies prior to abrasive blasting. Abrasive blasting operations shall comply with the requirements of OSHA and NIOSH (National Institute for Occupational Safety and Health) Standard PB-246-697.

3. Surfaces shall be free of any deleterious materials such as laitance, dust, dirt, and oil.

4. Any exposed reinforcing steel shall also be cleaned and be free of rust and other contaminants. Cleaning shall be accomplished by mechanical means. Use powered wire brushes in locations where reinforcing steel cannot be cleaned by abrasive-blasting or water-blasting. All exposed reinforcing steel shall be coated with a corrosion inhibiting product specified elsewhere in this specification prior to mortar application.

5. Prime the cleaned surface with primer as required by the manufacturer.

C. Concrete Surface Inspection

1. Ensure that the surface temperature is at least 40°F to permit wetting of concrete surface by epoxy coating.

2. The Contractor shall evaluate the moisture content of concrete surface receiving epoxy mortar. This shall be done by determining if moisture will collect at bond lines between concrete and epoxy mortar before epoxy has cured. Evaluate this by taping a piece of polyethylene sheet to the concrete. If moisture collects on underside of the polyethylene sheet before epoxy would cure, then allow concrete to dry sufficiently to prevent the possibility of moisture between old concrete and new epoxy.

D. Mortar Application

1. Condition epoxy compound components to a temperature between 65°-80°F unless otherwise recommended by the manufacturer. Epoxies beyond this range of temperature shall not be used.

2. Stir each of the two parts of epoxy separately before mixing. Then mix in a clean container free of contaminants.

3. Thoroughly blend epoxy components and sand with “Jiffy” mixers or equal to a uniform and homogenous mixture. Small batches of one quart or less may be mixed by spatulas, pallette knives or similar devices.

4. Mixing should be accomplished well within the pot life of epoxy (three minutes when using “Jiffy” mixer or five minutes when mixed by hand) after allowing for time required for application.

5. Apply mortar by trowel or other means suitable for the consistency of the epoxy-sand mortar mix.

6. Build up the repair area in layers with mortar thicknesses within those specified by the manufacturer (1/4" maximum per layer).

7. Consolidate the mortar thoroughly to remove entrapped air.

8. Finish surface of mortar to match the texture and contours of existing concrete.

9. Allow mortar to cure in accordance to manufacturers recommendations.

E. Cleanup

1. Protect surfaces surrounding the work areas against spillage.

2. Epoxy and epoxy mortar spillages shall be cleaned before they set and become difficult to remove.

3. Cleanup all portions of the existing structure that are soiled or stained in the process of epoxy mortar repair work.

3.3 POLYMER MODIFIED CEMENTITIOUS MORTAR PATCH

A. Applicator's Qualifications

1. Mortar repair work shall only be performed by contractors who have successfully used this process on at least three similar structural repairs of equal scope which have performed successfully for a minimum period of five years.

2. Only adequately trained and experienced personnel shall be used on the job.

B. Surface Preparation

1. Concrete surface to which the mortar is to be applied shall be exposed parent concrete free of loose and unsound materials. Surface preparation shall be done by abrasive-blasting, water-blasting or as otherwise required by the manufacturer.

2. Necessary approvals shall be obtained by the Contractor from authorizing governmental or other agencies prior to abrasive-blasting. Abrasive-blasting operations shall comply with the requirements of OSHA and NIOSH (National Institute for Occupational Safety and Health) Standard PB-246-697.

3. Surfaces shall be free of any deleterious materials such as laitance, dust, dirt, and oil.

4. Any exposed reinforcing steel shall also be cleaned and free of rust and other contaminants. Cleaning shall be accomplished by mechanical means. Use powered wire brushes in locations where reinforcing steel cannot be cleaned by abrasive-blasting or water-blasting. All exposed reinforcing steel shall be coated with a corrosion inhibiting product specified elsewhere in this specification prior to mortar application and shall comply with OSHA safety requirements.

5. Prime the cleaned surface with primer as required by the manufacturer.

C. Concrete Surface Inspection: Ensure that the surface and ambient temperature is at least 45°F and rising at the time of application.

D. Mortar Application

1. Condition polymer mortar material to 65°F-80°F unless otherwise recommended by the manufacturer. Materials beyond this range of temperature shall not be used.

2. Mix the two components in a clean container free of contaminants as recommended by the manufacturer.

3. Thoroughly blend components and aggregates with “Jiffy” mixers or equal to a uniform and homogenous mixture. Small batches of one quart or less may be mixed by spatulas, pallette knives or similar devices.

4. Mixing should be accomplished within three minutes when using “Jiffy” mixer or five minutes when mixed by hand.

5. Apply mortar by means suitable for the consistency of the mortar mix.

6. Use permanent fiberglass cloth forms for retaining mortar if mixed to a flowable consistency.

7. Consolidate the mortar thoroughly to remove entrapped air.

8. Finish surface of mortar to match the texture and contours of existing concrete.

9. Allow mortar to cure in accordance to manufacturer's recommendations.

E. Cleanup

1. Protect surfaces surrounding the work areas against spillage.

2. Epoxy and mortar spillage shall be cleaned before they set and become difficult to remove.

3. Cleanup all portions of the existing structure that are soiled or stained in the process of mortar repair work.

3.4 EPOXY BONDING OF FRESH (PLASTIC) CONCRETE TO HARDENED CONCRETE

A. Applicator's Qualifications

1. Epoxy bonding of fresh concrete to hardened concrete shall only be performed by contractors who have had successful experience in bonding concrete on a minimum of three projects of similar scope.

2. Only adequately trained epoxy applicators shall be used on the job. Furnish certificates of training on request.

B. Surface Preparation

1. Remove loose concrete, debris, laitance, oil, grease and other contaminants from surface receiving epoxy. All surfaces shall be clean, sound and free of surface water.

2. Clean concrete surface by abrasive blasting prior to applying epoxy bonder. Abrasive blasting shall take place no more than one day prior to bonding fresh concrete.

3. The Contractor shall obtain all necessary permits from all governmental, environmental, and other agencies having jurisdiction over the area where the abrasive blasting work is to be performed. Abrasive blasting operations shall comply with the requirements of OSHA and NIOSH (National Institute for Occupational Safety and Health) Standard PB-246-697.

4. Remove all abrasive from work area by vacuuming or other appropriate means. Remove blast cleaning residue with compressed air from an oil-and-water-free compressed air source prior to epoxy application.

5. Provide all necessary barriers to contain abrasive within the work area. The Contractor is responsible for all damage to property or injury to people as a result of sandblasting.

C. Epoxy Application

1. Condition epoxy compound materials at a temperature between 65°-80°F unless otherwise recommended by the manufacturer. Epoxies beyond this range of temperature shall not be used.

2. Mix epoxy materials in a clean container free of contaminants.

3. Thoroughly blend epoxy components with mechanical mixers to a uniform and homogenous mixture.

4. Mixing shall be accomplished well within the pot life of the epoxy after allowing for time required for application.

5. Apply epoxy adhesive to concrete surface by brush, roller, broom, squeegee, or spray equipment. The minimum average application thickness shall be between 15-18 mils for normal weight concrete. For lightweight concrete, use a second coat of epoxy bonder having a minimum average thickness of 15 mils. Application of epoxy shall be in strict accordance with manufacturer's instructions.

6. Do not apply epoxy bonder in rain or in the presence of standing water.

7. Do not let the epoxy adhesive reach the gel stage before pouring concrete. This can be determined by checking whether the adhesive is still tacky. If the adhesive loses its tack before plastic concrete is placed, remove the epoxy by abrasive blasting or other suitable means prior to reapplying the epoxy adhesive.

8. Production, placing, consolidation and curing of new concrete shall conform to ACI 301-99 and the project specifications.

D. Cleanup

1. Protect surfaces surrounding the work areas against spillage.

2. Epoxy spillages shall be cleaned before they set and become difficult to remove.

3. Cleanup whatever portions of the existing structure that are soiled or stained in the process of applying epoxy adhesive.

E. Testing

1. The Engineer and Testing Laboratory shall evaluate bonding of fresh concrete to existing concrete after the fresh concrete has sufficiently cured.

2. The evaluation shall be performed by sounding, using one of the following, or similar, methods:

a. Tapping fresh concrete with a blunt metal instrument.
b. Dragging a heavy steel chain across the surface (for horizontal surfaces only).

3. Detection of a hollow sound in any area shall be reason to suspect inadequate bonding, and Contractor shall then core each such area, as required by the Engineer, to determine bonding adequacy.

4. Coring shall be through the new concrete and into the existing concrete. Core diameter shall be 4" unless specified otherwise by the Engineer. Length of cores shall be twice the core diameter, or twice the thickness of new concrete, or as specified by the Engineer.

5. Cores will be visually inspected, and further testing may be required as determined by the Engineer.

6. The cost of any repairs or replacement, and any additional cores or other testing deemed necessary by the Engineer, shall be borne by the Contractor.

3.5 EPOXY GROUTED BOLTS, DOWELS OR REINFORCING STEEL

A. Applicator's Qualifications

1. Epoxy grouting of bolts, dowels or reinforcing steel shall only be performed by contractors who have had successful experience on a minimum of three projects of similar scope.

2. Only adequately trained epoxy applicators shall be used on the job. Furnish current certificate of training on request.

B. Surface Preparation

1. All bolts, dowels and reinforcing bars shall be abrasive blasted no more than eight hours before the grouting. If evidence of oxidation exists on the surface, the bolts, reinforcing bars and dowels shall be recleaned. Blast-clean surfaces using Steel Structures Painting Council, Surface Preparation No. 6, to give a surface condition corresponding to ASa2, BSa2, CSa2 of SSPC Vis 1, depending on the initial surface condition of the steel surface. Prior to blast-cleaning, clean surfaces to conform to SSPC SP1, SP2, and SP3, as required.

2. Unless otherwise printed in manufacturer’s instructions, all holes shall be clean of dust, debris, and contaminants. Use compressed air from an oil-and-water-free compressed air source prior to epoxy application.

C. Drilling Holes for Embedment

1. Use only rotary-percussion type drills for drilling holes.

2. Drills shall be fitted with bits having single tooth that produce large cuttings, and hollow stem drill rods that permit simultaneous blowing of compressed air providing immediate expulsion of the cuttings from the hole.

3. Do not cut through any reinforcing steel unless indicated otherwise on the drawings. Where significant amounts of reinforcing are expected, use non-destructive techniques to determine location of reinforcing steel prior to drilling.

Otherwise, use small diameter exploratory holes to detect presence of reinforcing steel prior to drilling holes for grouting.

4. Core drilling equipment, and electric impact hammers or other tools which do not provide for immediate expulsion of the drill cuttings shall not be used.

5. Unless noted otherwise on the drawings, depth of holes used for embedding the bolts, bars or dowels shall be at least ten times their diameter, but not less than 6".

6. Unless noted otherwise on the drawings, depth of hole used for embedding the bolts, bars or dowels shall be at least fifteen times their diameter.

7. Unless noted otherwise on the drawings, the center to center distance between the embedded bolts, bars or dowels shall be at least twelve times their diameter.

8. Unless noted otherwise on the drawings, the edge distance shall be at least six times the diameter of the bolt, bar or dowel.

9. Hole diameter shall normally be 1/4" larger than the outside diameter of the embedded item. In no case shall the hole diameter be 3/8" larger than the diameter of the embedded item.

D. Epoxy Application

1. Condition epoxy compound materials at a temperature between 65°-80°F unless otherwise recommended by the manufacturer. Epoxies beyond this range of temperature shall not be used.

2. Mix epoxy materials in a clean container free of contaminants.

3. Thoroughly blend epoxy components with mechanical mixers to a uniform and homogenous mixture. Mix small batches (up to 1 quart) by use of spatulas, pallette knives, or similar devices. Take care to use proper proportions of the epoxy components when using small batches.

4. Mixing shall be accomplished well within the pot life of the epoxy after allowing for time required for application.

5. Partially fill the hole with epoxy. Then insert the bolt, dowel or reinforcing bar into the hole such that the resin material oozes out around the embedded item, ensuring complete contact. Twist the bolt, dowel or bar slightly as it is inserted in the hole to ensure complete contact.

6. As an alternative to inserting the embedded item after the epoxy is poured in the hole, the bolt, dowel, or bar may be positioned in the hole and filled up with epoxy by hand caulking guns or injected with an in-head mixing equipment. In either case, the nozzle shall be provided with a hose or tube of sufficient length to reach the bottom of the hole being filled.

7. Where the holes are horizontal or overhead, the opening shall be covered by a masking or a duct tape. Make a split in the tape and insert the epoxy injection tube through the split. Fill hole completely with epoxy and then insert the embedded item through the split tape. Amount of epoxy should be such that a

small amount of material oozes through the split. Twist the bolt, dowel or bar slightly as it is inserted in the hole to ensure complete contact.

8. Do not apply epoxy in the rain or in the presence of standing water unless permitted by manufacturer's written instructions.

E. Cleanup

1. Protect surfaces surrounding the work area against spillage.

2. Epoxy oozed out from the holes and spillages shall be cleaned before they become difficult to remove.

3. Cleanup whatever portions of the existing structure are soiled or stained in the process of grouting the bolts, dowels or reinforcing bars.

F. Testing

1. The Owner's Testing Laboratory shall evaluate the effectiveness of grouting the bolts, dowels, or reinforcing bars by conducting field proof tests. The load test method shall be submitted to the Engineer for review and approval.

2. Field proof test 10% of the grouted bolts, dowels or bars, with a minimum of two tests prior to commencing installation.

3. The Engineer may elect to increase or decrease the number of tests depending upon the outcome of the tests.

4. The proof load shall be 85% of the theoretical ultimate strength of the bolt, dowel or bar or as otherwise determined by the Engineer. Any slip of the embedded bolt, dowel or bar within the epoxy grout material, or slip at the epoxy/concrete interface before the bolt, dowel or bar yields shall be considered to be a failure of the grouted item.

5. The cost of any repairs failing to meet the proof load and all additional tests deemed necessary by the Engineer shall be borne by the Contractor.

3.6 EPOXY FOR PRODUCING SKID RESISTANT SURFACE ON CONCRETE

A. Applicator's Qualifications

1. Work requiring epoxy application for producing skid resistant surfaces on concrete shall only be performed by contractors who have had successful experience in applying epoxy on at least three projects of similar scope.

2. Only adequately trained epoxy applicators shall be used on the job. Furnish certificates of training on request.

B. Surface Preparation

1. Remove loose concrete, debris, laitance, oil, grease and other contaminants from surface receiving epoxy. All surfaces shall be clean, sound, and free of surface water.

2. Clean concrete by mechanical abrasion such as abrasive blasting, scarifying, or waterblasting and as required by the manufacturer.

3. The Contractor shall obtain all necessary permits from all governmental, environmental and other agencies having jurisdiction over the area where the mechanical abrasion work is to be performed. Abrasive blasting operations shall comply with the requirements of OSHA and NIOSH (National Institute for Occupational Safety and Health) Standard PB-246-697.

4. Where abrasive blasting is used, all abrasive shall be removed from the work area by vacuuming or other appropriate means. Remove blast cleaning residue with compressed air from an oil-and-water-free compressed air source prior to epoxy application.

5. Provide all necessary barriers to contain the abrasive material within the work area. The Contractor is responsible for all damage to property or injury to people as a result of mechanical abrasion process.

C. Epoxy Application

1. Condition epoxy compound material to be at a temperature between 65°-80°F unless otherwise recommended by the manufacturer. Epoxies beyond this range of temperature shall not be used.

2. Stir each of the two parts of epoxy separately before mixing. Then mix the two parts in a clean container free of contaminants.

3. Thoroughly blend epoxy components with mechanical mixers to a uniform and homogenous mixture.

4. Mixing shall be accomplished well within the pot life of the epoxy after allowing for time required for application.

5. Apply epoxy adhesive to concrete surface by brush, roller, broom, squeegee, or spray equipment. The minimum average application thickness shall be between 50-70 mils. Application shall be in strict accordance to manufacturer's instructions.

D. Skid-Resistant Aggregate Application: Apply the skid-resistant aggregate while the epoxy coating is still fluid at the rate of 11-13 pounds per square yard. The aggregate shall be spread uniformly over the entire surface of the concrete.

E. Cleanup

1. Protect surfaces surrounding the work area against spillage.

2. Epoxy spillages shall be cleaned before they set and become difficult to remove.

3. Cleanup whatever portions of the existing structure that are soiled or stained in the process of applying epoxy adhesive.

F. Testing

1. The Testing Laboratory shall evaluate that the thickness of the epoxy adhesive and the amount of skid-resistant aggregate complies to the specifications.

2. The Testing Laboratory shall perform pullout tests on the cured skid-resistant surface. The rate of testing shall be one test for every 1000 square feet of surface area, with a minimum of three tests. The pullout strength (tested in accordance with Appendix A of ACI 503 R-93) shall be at least 100 psi. All failures shall be in the concrete. Any failure that occurs in the adhesive shall be cause for rejection of the coating application.

3. The cost of replacement and any retesting required by the Engineer shall be borne by the Contractor.

3.7 EPOXY PENETRANT SEALER

A. Applicator's Qualifications

1. Work requiring epoxy penetrant sealer on concrete surfaces shall only be performed by contractors who have had successful experience in applying epoxy on at least three projects of similar scope.

2. Only adequately trained epoxy applicators shall be used on the job. Furnish certificates of training on request.

B. Surface Preparation

1. Remove loose concrete, debris, laitance, oil, grease and other contaminants from surface receiving epoxy. All surfaces shall be clean, sound, and free of surface water.

2. Clean concrete by mechanical abrasion such as abrasive blasting or waterblasting.

3. The Contractor shall obtain all necessary permits from all governmental, environmental and other agencies having jurisdiction over the area where the mechanical abrasion work is to be performed. Abrasive blasting operations shall comply with the requirements of OSHA and NIOSH (National Institute for Occupational Safety and Health) Standard PB-246-697.

4. Where abrasive blasting is used, all abrasive shall be removed from the work area by vacuuming or other appropriate means. Remove blast cleaning residue with compressed air from an oil-and-water-free compressed air source prior to epoxy application. Ensure compatibility of concrete curing method and use of this product.

5. Provide all necessary barriers to contain the abrasive material within the work area. The Contractor is responsible for all damage to property or injury to people as a result of mechanical abrasion process.

C. Epoxy Application

1. Temperature of the epoxy must be above 50° for mixing.

2. Stir each of the two parts of epoxy separately before mixing. Then mix the two parts in a clean container free of contaminants.

3. Thoroughly blend epoxy components using a “Jiffy” mixer or equal powered by a low-speed (300-600 rpm) electric drill for at least three minutes.

4. When mixing has been completed, cover mixed epoxy penetrant sealer container and allow a reaction time as required by the manufacturer before applying.

5. Apply the epoxy penetrant sealer when the surface temperature of concrete is at least 40°F with brush, roller or spray equipment. All spray equipment must employ traps to prevent water and oil from contaminating the sealant. Two applications are required at the following rates:

First application:	200-300 sft/gallon
Second application:	250-300 sft./gallon

The second coat shall be applied as soon as the first coat is tack-free. If a surface film develops on the concrete, the application rate should be reduced. (Second coat is not needed with Sikagard 619 when applied at the rate of 300 sft/gallon.

D. Cleanup

1. Protect surfaces surrounding the work area against spillage.

2. Epoxy spillages shall be cleaned before they set and become difficult to remove.

3. Cleanup whatever portions of the existing structure that are soiled or stained in the process of applying the epoxy penetrant sealer.

E. Testing: The Testing Laboratory shall monitor the rate of application of the epoxy penetrant sealer.

3.8 HIGH MOLECULAR WEIGHT METHACRYLATE SELF-PENETRATING CONCRETE CRACK FILLER AND SEALER

A. Applicator's Qualifications

1. Work requiring self-penetrating crack filler and sealer on concrete shall only be performed by contractors who have had successful experience in applying the methacrylate sealer on at least three projects of similar scope.

2. Only adequately trained applicators shall be used on the job. Furnish certificates of training on request.

B. Surface Preparation

1. Remove loose concrete, debris, laitance, oil, grease and other contaminants from surface and cracks receiving sealer. All surfaces shall be clean, sound, and free of surface moisture.

2. Clean concrete by mechanical abrasion such as abrasive blasting.

3. The Contractor shall obtain all necessary permits from all governmental, environmental and other agencies having jurisdiction over the area where the mechanical abrasion work is to be performed. Abrasive blasting operations shall comply with the requirements of OSHA and NIOSH (National Institute for Occupational Safety and Health) Standard PB-246-697.

4. Where abrasive blasting is used, all abrasive shall be removed from the work area by vacuuming or other appropriate means.

5. Remove blast cleaning residue with compressed air from an oil-and-water-free compressed air source prior to self-penetrating crack filler and sealer application. Surface receiving sealer shall be dry, and all cracks shall be free of standing water. Blow cracks clean with compressed air prior to sealer application.

6. All spalls in concrete in the area scheduled to receive the methacrylate sealer shall be repaired using polymer concrete mortar patch prior to sealer application.

7. Temporarily plug all existing drains with rubber plugs or other suitable material to prevent the sealer from getting into the drains.

8. Protect expansion joints from being covered by methacrylate material. All expansion joints which get accidentally covered with the sealer shall be cleaned immediately. All damaged joints shall be repaired or replaced as directed by the Architect/Engineer at no cost to the Owner.

C. Methacrylate Application

1. Do not schedule methacrylate sealer work if there is forecast of rain within twelve hours, or if the ambient temperature is expected to fall below 45°F temperature during application or within twelve hours after application of the sealer.

2. Stir each of the two parts of sealer separately before mixing. Then mix the two parts in a clean container free of contaminants.

3. Condition sealer materials at a temperature between 65°-80°F unless otherwise recommended by the manufacturer in writing. Methacrylate materials beyond this temperature range shall not be used.

4. Thoroughly blend the methacrylate components using a “Jiffy” mixer or equal powered by a low-speed (300-600 rpm) electric drill for five to seven minutes until the liquid clears.

5. Apply the material on horizontal surfaces with roller or squeegee at the rate of approximately 130 square feet per gallon. The concrete substrate must be at a temperature of at least 45°F. Material shall be allowed to pond over cracks. After penetration into the substrate and cracks, remove excess material.

6. Application of sealer shall proceed in an orderly manner in widths between 6 to 10 feet across the length of the work. Overlap shall be kept to a minimum with no overlap exceeding 6 inches.

7. Follow additional directions for surface preparation and application given in the manufacturer's printed technical specifications which are not included in these specifications. The Contractor shall have these specifications with him at the job site prior to start of the work.

8. Apply second coat of methacrylate sealer at the rate of 200 square feet per gallon in the same orderly manner as used for the first coat.

9. Spread sand by mechanical means over the surface treated by the methacrylate sealer at a rate of 0.50 pounds per square yard of surface area. Sand shall be

broadcast within 15 to 35 minutes following the application of the sealer. Sand shall be spread over the width which coincides with the width of the methacrylate sealer. Sand spreader equipment used shall be operated at speeds which will eliminate sand drifts and spread the sand uniformly over the treated area. Excess sand shall be removed completely from the untreated area by brooming or other means prior to application of the methacrylate sealer.

10. Protect sand covered area by covering with a polyethylene sheet. No vehicular traffic shall be allowed on the surface until the methacrylate sealer has cured.

11. Remove all loose sand from the slab prior to opening the area for traffic.

D. Test Area

1. See the drawings for location and size of test area.

2. Contractor shall use the same workers, and materials for applying the methacrylate sealer and the sand to the test area as for the rest of the work. Method of surface preparation and application shall be in strict accordance to these specifications and the manufacturer's printed directions.

3. Contractor shall inform the Owner, Testing Laboratory, Architect/Engineer regarding the schedule for performing the work in the test area. It is mandatory that the manufacturer's representative be also present during the application of the material in the test area.

4. The Testing Laboratory and the Contractor shall accurately record the quantity of material used and calculate the rate of coverage. Adjustments shall be made immediately, and the size of test area increased accordingly to apply material at the rate given in the specifications.

5. Provide a watertight dam around the test area capable of holding at least 3 inches of water for 48 hours. Fill with water and mark the level. Ensure that there is no leakage around the perimeter of the dam. Leave the water standing in the test area for 48 hours. Cover area with polyethylene sheet to prevent evaporation.

6. The Testing Laboratory shall measure water level after 48 hours, and also check soffit of slab under test area for evidence of leaks. If no leak is observed, the methacrylate sealer application shall be considered acceptable and the Contractor shall proceed with the work.

7. If leaks are observed, do not proceed with the rest of the work.

E. Cleanup

1. Protect surfaces surrounding the work area against spillage.

2. Sealer spillages shall be cleaned before they set and become difficult to remove.

3. Cleanup whatever portions of the existing structure that are soiled or stained in the process of applying the methacrylate sealer.

F. Testing: The Testing Laboratory shall perform the following work:

1. Check the materials to ensure that they conform to the specifications.

2. Review the storage facility and the temperature at which the material is stored.

3. Review the surface preparation to ensure that the surface is clean as required in the specifications.

4. Review mixing and application procedures.

5. Test sand to ensure that it complies with the specifications.

6. Review procedures for application of sand to ensure that the rate of coverage is in accordance to the specifications.

3.9 POLYMER MODIFIED CEMENTITIOUS MORTAR OVERLAY SYSTEM

A. Applicator's Qualifications

1. Mortar overlay system work shall only be performed by contractors who have successfully used this process on at least three similar structural repairs of equal scope which have performed successfully for a minimum period of five years.

2. Only adequately trained and experienced personnel shall be used on the job.

B. Surface Preparation

1. Concrete surface to which the mortar is to be applied shall be exposed parent concrete free of loose and unsound materials. Surface preparation shall be done by using a scabbler. Obtain a surface profile having a minimum amplitude of ± 1/16".

2. Surface shall then be swept clean or vacuumed to clear off debris and dust.

3. Wash surface with water and brush with hard broom to remove all contaminants and oil drippings. Oil and grease spots shall be removed by using a detergent, and then scrubbing with a power brush or a hard broom. Remove all residue by washing and brushing with water.

4. Surface then shall be wet vacuumed to remove excess water.

5. Surface to be prepared shall be wetted prior to and during scarification by a scabbler to minimize the creation of dust.

6. Provide adequate barricades around the work area to prevent injury to people around the work area from flying debris.

7. Ensure that all edges, corners, areas adjacent to columns, walls and doors are satisfactorily prepared as described above. Use small pneumatic bush-hammer or single-head scabbler for preparing such areas.

8. Any exposed reinforcing steel shall also be cleaned and free of rust and other contaminants. Cleaning shall be accomplished by mechanical means. Use powered wire brushes or abrasive-blasting. All exposed reinforcing steel shall be coated with a corrosion inhibiting product specified elsewhere in this specification prior to mortar application.

C. Concrete Surface Inspection

1. Ensure that the surface and ambient temperature is at least 45°F and rising at the time of application.

2. Inspect surface for loose aggregate and concrete particles. Remove all loose concrete.

3. Inspect surface for cracks. All cracks shall be rebonded prior to application of the overlay system.

D. Crack Repair – Method shall be chosen by Engineer

1. Rebond cracks using epoxy injection procedures given elsewhere in these specifications.

** OR **

2. Rebond cracks using self-penetrating concrete crack filler and sealer using high molecular weight methacrylates. Procedures for filling cracks are given elsewhere in these specifications.

** OR **

3. Rebond cracks using both epoxy injection and self-penetrating concrete crack filler and sealer using high molecular weight methacrylate procedures. See drawings for areas requiring the different methods of repair.

E. Mortar Application

1. Condition polymer mortar material to 65°F-80°F unless otherwise recommended by the manufacturer. Materials beyond this range of temperature shall not be used.

2. Mix the two components in a clean mortar mixer free of contaminants as recommended by the manufacturer.

3. Thoroughly blend components and aggregates with “Jiffy” mixers or equal to a uniform and homogenous mixture.

4. Mixing should be accomplished within three minutes when using “Jiffy” mixer.

5. Dampen the surface of concrete receiving the mortar by a portable sprayer just prior to mortar application. The surface shall be saturated surface dry with no standing water.

6. Set the screed to the proper overlay thickness. See drawings for required overlay thickness. Contractor shall use only power vibrating screeds with metal edges to obtain a smooth wet finish.

7. Spread mortar uniformly on the damp surface by broom. Scrub into substrate filling all pores and voids.

8. Consolidate the mortar thoroughly to remove entrapped air.

9. After screeding, wait for a few minutes as recommended by the manufacturer such that the mortar has a desired stiffness. Wait time depends on the ambient temperature and temperature of the applied material. Then finish by power trowel. Small, difficult to reach areas may be finished by hand troweling. Use water from a portable sprayer during the troweling process.

** OR **

10. After screeding, wait for a few minutes as recommended by the manufacturer such that the mortar has a desired stiffness. Wait time depends on the ambient temperature and temperature of the applied material. Then apply a broom finish on the surface parallel to the direction of flow of traffic.

F. Compressive Strength Test Cubes

1. The Testing Laboratory shall take a minimum of one set of four cube compressive strength test samples to be tested in accordance with ASTM C-109-99 (modified) for every 10 cubic feet of mortar used in overlay or part thereof in a day's work.

2. Test one cube after 24 hours, second cube after 72 hours (3 days), third cube after 14 days, and fourth cube after 28 days.

G. Joints in Overlay System

1. All joints in the original surface or floor shall be reproduced in the overlay. Provide any additional joints shown in the drawings.

2. Joints in the overlay shall be produced by saw-cutting.

   a. Make saw cut as soon as overlay is able to support weight of workers and sawing equipment without damage to finish surface of overlay.
   b. All joints shall be continuous across the overlay. Do not offset or stagger joints.
   c. Width of saw cut shall be 1/4". Saw cut shall be made through the full thickness of the overlay.

H. Joint Filler Material

1. Joint filler material shall be scheduled to be applied in the last week of the construction work.

2. Joint filler material shall be applied immediately after the sawcut is made. However, a week prior to completion of the entire work, reinspect the joints. Repair and refill any joints that show gaps or tears.

3. Clean joint thoroughly prior to filling the joint. There shall be no water in the joint at the time of filler application.

4. Fill joint with filler material having a Shore A hardness of 35 or 80, as chosen by the Engineer.

5. Condition the joint material at a temperature between 65°-80°F unless otherwise recommended by the manufacturer. Joint material beyond this range shall not be used.

6. Follow strictly the manufacturer's recommended procedures for applying the joint filler.

I. CURING

1. Unless otherwise written in manufacturer’s instructions and approved by Engineer, cure finished surface by applying a fine mist spray of water over the finished surface. Alternatively, cover with wet burlap. Solvent type curing compounds shall not be used on the overlay system.

2. Curing shall start immediately after the finishing work is completed.

3. Overlay shall be maintained in a moist condition for a minimum of 24 hours.

4. Overlay shall be maintained in a moist condition for a minimum of 72 hours.

5. Protect overlay work from rain and freezing conditions. Contractor shall ensure that the overlay is protected by proper insulation in the event freezing conditions are expected during the curing period.

J. CLEANUP

1. Protect surfaces surrounding the work areas against spillage.

2. Mortar and joint filler material spillage shall be cleaned before they set and become difficult to remove.

3. Cleanup all portions of the existing structure that are soiled or stained in the process of mortar repair work.

K. OVERLAY SERVICE

1. Protect overlay from foot and vehicular traffic as well as equipment loads during the curing period, or until the overlay mortar has attained a compressive strength of 4,000 psi.

2. Strength shall be determined from cube compressive strength tests performed in accordance to ASTM C-109-99 (Modified).

3.10 EPOXY RESIN FLOOR OVERLAY SYSTEM

A. Applicator's Qualifications

1. Work requiring epoxy resin floor overlay system on concrete shall only be performed by contractors who have had successful experience in applying epoxy overlay systems on at least three projects of similar scope which have performed successfully for a minimum period of five years.

2. Only adequately trained epoxy applicators shall be used on the job. Furnish certificates of training on request.

B. Surface Preparation

1. Remove loose concrete, debris, laitance, oil, grease and other contaminants from surface receiving epoxy. All surfaces shall be clean, sound, and free of surface water.

2. Clean concrete by mechanical abrasion such as abrasive blasting, shotblasting, scarifying, waterblasting or as required by the manufacturer. Remove all projections and rough spots to achieve a level clean surface.

3. The Contractor shall obtain all necessary permits from all governmental, environmental and other agencies having jurisdiction over the area where the mechanical abrasion work is to be performed. Abrasive blasting operations shall comply with the requirements of OSHA and NIOSH (National Institute for Occupational Safety and Health) Standard PB-246-697.

4. Where abrasive blasting is used, all abrasive shall be removed from the work area by vacuuming or other appropriate means. Remove blast cleaning residue with compressed air from an oil-and-water-free compressed air source prior to epoxy application.

5. Provide all necessary barriers to contain the abrasive material within the work area. The Contractor is responsible for all damage to property or injury to people as a result of mechanical abrasion process. Wet surface during the surface preparation process to minimize the creation of dust. Alternatively, use equipment designed to perform abrasive blasting and vacuuming operations simultaneously which eliminates dust.

6. Any exposed reinforcing steel shall also be cleaned and free of rust and other contaminants. Cleaning shall be accomplished by mechanical means. Use powered wire brushes or abrasive-blasting. All exposed reinforcing steel shall be coated with a corrosion inhibiting product specified elsewhere in this specification prior to epoxy application.

C. Concrete Surface Inspection

1. Ensure that the surface and ambient temperature is at least 45°F and rising at the time of application.

2. Inspect surface for loose aggregate and concrete particles. Remove all loose concrete.

3. Inspect surface for cracks. All cracks shall be rebonded prior to application of the overlay system.

D. Crack Repair

1. Rebond cracks using epoxy injection procedures given elsewhere in these specifications.

** OR **

2. Rebond cracks using self-penetrating concrete crack filler and sealer using high molecular weight methacrylates. Procedures for filling cracks are given elsewhere in these specifications.

** OR **

3. Rebond cracks using both epoxy injection and self-penetrating concrete crack filler and sealer using high molecular weight methacrylate procedures. See drawings for areas requiring the different methods of repair.

E. Epoxy Primer Application

1. Condition epoxy compound material to be at a temperature between 65°-80°F unless otherwise recommended by the manufacturer. Epoxies beyond this range of temperature shall not be used.

2. Stir each of the two parts of epoxy separately before mixing. Then mix the two parts in a clean container free of contaminants.

3. Thoroughly blend epoxy components for 3 minutes with mechanical mixers having a speed of 400-600 rpm to a uniform and homogenous mixture.

4. Mixing shall be accomplished well within the pot life of the epoxy after allowing for time required for application.

5. Apply epoxy adhesive to concrete surface by brush, roller, broom, or squeegee. The minimum average application thickness shall be between 150-250 square feet per gallon. Application shall be in strict accordance to manufacturer's instructions.

F. Epoxy Mortar Application

1. Mix epoxy in the same manner as described above for epoxy primer.

2. While mixing the epoxy components, slowly add 5 parts by loose volume of oven-dried quartz sand to 1 part of the mixed epoxy material, and mix until uniform in consistency.

3. Place epoxy mortar before primer becomes tack free.

4. Place epoxy mortar with trowel. Compact and trowel with vibrating screed having metal edges. Set the screed for proper overlay thickness. See drawings for areas requiring overlay and overlay thickness required.

5. Finish overlay surface with finishing trowel or other mechanical means.

6. Allow epoxy mortar to cure in accordance to manufacturer's recommendations.

G. Compressive Strength Tests

1. The Testing Laboratory retained by the Owner shall take a minimum of one set of four cube compressive strength test samples to be tested in accordance with ASTM C-109-99 (Modified) for every 1000 square feet of epoxy overlay work or part thereof in a day's work.

2. Test one cube after 24 hours, second cube after 72 hours (3 days), third cube after 7 days, and fourth cube after 28 days.

H. Seal Coat: Allow the overlay system to reach sufficient cure so as not to be damaged by foot traffic (minimum compressive strength 2,000 psi). Then apply a top seal coat of neat epoxy over the epoxy mortar overlay by means of a roller or flat squeegee. Method of

mixing the seal coat epoxy resin and its rate of application shall be the same as that of the epoxy primer.

I. Joints in Overlay System

1. All joints in the original surface or floor shall be reproduced in the overlay. Provide any additional joints shown in the drawings.

2. Joints in the overlay shall be produced by saw-cutting.

   a. Make saw cut as soon as overlay is able to support weight of workers and sawing equipment without damage to finish surface of overlay.
   b. All joints shall be continuous across the overlay. Do not offset or stagger joints.
   c. Width of saw cut shall be 1/4". Saw cut shall be made through the full thickness of the overlay.

J. Joint Filler Material

1. Joint filler material shall be scheduled to be applied in the last week of the construction work.

2. Joint filler material shall be applied immediately after the sawcut is made. However, a week prior to completion of the entire work, reinspect the joints. Repair and refill any joints that show gaps or tears.

3. Clean joint thoroughly prior to filling the joint. There shall be no water in the joint at the time of filler application.

4. Fill joint with filler material having a Shore A hardness of 35 or 80, as chosen by Engineer.

5. Condition the joint material at a temperature between 65°-80°F unless otherwise recommended by the manufacturer. Joint material beyond this range shall not be used.

6. Follow strictly the manufacturer's recommended procedures for applying the joint filler.

K. Testing

1. The Testing Laboratory shall evaluate that the rate of coverage of the epoxy adhesive and the thickness of the overlay complies to the specifications.

2. The Testing Laboratory shall perform pullout tests on the cured overlay surface prior to applying the seal coat. The rate of testing shall be one test for every 1000 square feet of surface area, with a minimum of three tests. The pullout strength (tested in accordance with Appendix A of ACI 503 R-93) shall be at least 100 psi. All failures shall be in the concrete. Any failure that occurs in the adhesive shall be cause for rejection of the overlay system.

3. The cost of replacement and any retesting required by the Engineer shall be borne by the Contractor.

4. Repair all tested areas in the same manner as the overlay system application.

L. Cleanup

1. Protect surfaces surrounding the work area against spillage.

2. Epoxy spillages shall be cleaned before they set and become difficult to remove.

3. Cleanup whatever portions of the existing structure that are soiled or stained in the process of applying epoxy adhesive.

END OF SECTION 03 31 00

SECTION 033519

COLORED CONCRETE TOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes sand-cushion integrally colored concrete topping.

B. Related Sections include the following:

1. Division 03 Section "Cast-in-Place Concrete" for concrete strength and mix requirements.

1.2 SUBMITTALS

A. Product Data: For each type of color, component material, and accessory specified.

B. Shop Drawings: Show topping fabrication and installation requirements including plans, sections, component details, and attachments to other work.

1. Show layout of divider and control- and expansion-joint strips.
2. Show layout of base and border strips.
3. Show layout of abrasive strips.
4. Show large-scale details of patterns.

C. Samples for Verification: Minimum of three 6-inch square samples of each topping color and type required, showing the full range of color, and texture variations expected. Prepare samples of the same thickness and from the same material to be used for the Work. Provide minimum 6-inch long samples of each exposed strip item required.

D. Qualification Data: For firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

E. Material Certificates: Certificates signed by suppliers or manufacturers certifying that each material complies with requirements.

F. Maintenance Data: For topping to include in the maintenance manuals specified in Division01.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has completed topping installations similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

B. Source Limitations for Color: Obtain colors for entire installation from one source with resources to provide materials of consistent quality in appearance and physical properties without delaying the Work.

C. Mockups: Before installing color topping, construct mockups for each type and color required to verify selections made under Sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for completed Work.

1. Locate mockups in the location and of the size indicated or, if not indicated, as directed by Architect.
2. Notify Architect 7 days in advance of dates and times when mockups will be constructed.
3. Demonstrate the proposed range of aesthetic effects and workmanship. Include divider strips and show quality of troweled finish.
4. Obtain Architect's approval of mockups before proceeding with topping installation.
5. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

    a. When directed, demolish and remove mockups from Project site.

D. Pre-installation Conference: Conduct conference at Project site to comply with requirements of Division 1 Section "Project Meetings." Review methods and procedures related to installation including, but not limited to, the following:

1. Inspect and discuss condition of substrate and other preparatory work performed by other trades.
2. Review structural loading limitations.
3. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in suppliers' original wrappings and containers, labeled with source's or manufacturer's name, material or product brand name, and lot number, if any.

B. Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Maintain temperature above 50 deg F (10 deg C) for 48 hours before and during installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering integral color system that may be incorporated into the Work include, but are not limited to, the following:

1. L. M. Scofield Company, Chromix.
2. Or approved equal.

2.2 MATERIALS

A. Portland Cement: ASTM C 150, Type 1.

1. Color: As required by mix indicated.

B. Water: Potable.

C. Sand: ASTM C 33.

D. Pigments: Pure mineral or synthetic pigments, alkali resistant, color stable, and compatible with matrix binder.

E. Surface Hardener: Siliconate polymer type, Euclid Euco Diamond Hard or approved equal.

F. Reinforcement: As specified in Section 321313 Concrete Paving. Retain one divider-strip type below.

G. Divider Strips: Straight or angle type as required by topping pattern indicated, with anchoring device, in depth required for topping thickness indicated, and as follows:

1. Bottom-Section Material: Matching top section material.
2. Top-Section Material: White zinc alloy.
3. Top-Section Width: 1/8 inch.

H. Control-Joint Strips: Separate, double L-type angle or straight strips positioned back-to-back matching material, thickness, and color of divider strips in depth required for topping thickness indicated.

I. Abrasive Strips: Silicon carbide or aluminum oxide in epoxy-resin binder.

J. Abrasive-Strip Channel: 1/2-inch- wide-by-1/2-inch- deep, white zinc alloy or half-hard brass to match divider-strip material.

K. Accessory Strips: Match divider-strip width, material, and color, unless otherwise indicated. Use the following types of accessory strips as required to provide a complete installation:

1. Base bead and base dividers.
2. Edge beads for exposed edges of topping.

L. Isolation and Expansion Material: Closed cell polyethylene foam or silicone based sealant.

M. Expansion Joint Strips: Back to back divider strips with sealant. Sealant is specified in Division 07 Section Joint Sealants.

N. Sand-Cushion-Topping Isolation Membrane: Polyethylene sheeting, ASTM D 4397, 4 mils thick; or No. 15 un-perforated roofing felt complying with ASTM D 226, Type 1 requirements.

O. Divider-Strip Adhesive: Adhesive recommended by manufacturer for this use.

P. Curing Materials: As specified in Section 03300 and as recommended by coloring manufacturer.

2.3 MIXES

A. Concrete Topping: As specified in Division 03 Section "Cast-in-Place Concrete."

1. Colors: Match Architect's samples.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of topping. Do not proceed with installation until unsatisfactory conditions, including levelness tolerances, have been corrected.

3.2 INSTALLATION

A. Spread sand on surfaces to receive sand-cushion topping to comply with NTMA's "Guide Specification for Sand Cushion Terrazzo."

B. Install isolation membrane according to NTMA Guide Specification.

C. Install reinforcement, centering in topping.

D. Install divider and accessory strips according to NTMA's written recommendations.

1. Install divider strips at centers of joists or beams supporting metal deck.

E. Install control-joint strips back-to-back directly above substrate control joints.

F. Install angle- or T-type strips and similar accessories in adhesive setting bed without voids below strips. Provide mechanical anchorage of strips as required for adequate attachment of strips to substrate.

G. Install abrasive-strip channels according to NTMA's written recommendations.

H. Integrally Colored Concrete Topping: Place, cure, and finish to achieve approved mock-up installation.

I. Install abrasive strips as indicated with abrasive-strip surface projecting slightly above topping surface without causing a hazard.

J. Construction Tolerances: Limit topping surfaces' variation from level to 1/4 inch in 10 feet.

3.3 FINISHING

A. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Re-straighten, cut down high spots, and fill low spots. Repeat float passes and re-straightening until surface is left with a uniform, smooth, granular texture.

B. Trowel Finish: After applying float finish, apply first trowel finish and consolidate concrete by hand or power-driven trowel. Continue troweling passes and re-straighten until surface is free of trowel marks and uniform in texture and appearance.

C. Apply hardener following manufacturer’s instructions.

3.4 CLEANING AND PROTECTING

A. Provide final protection and maintain conditions, in a manner acceptable to Installer, that ensure the topping is without damage or deterioration at the time of Substantial Completion.

END OF SECTION 033519

SECTION 033519.13

SPECIAL CONCRETE FINISHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Dry-shake colored hardener applied to exterior concrete pavements.
2. Rock salt finishing applied to exterior concrete pavements.

1.2 RELATED SECTIONS

A. Related Sections include the following:

1. Division 03 Section "Cast-in-Place Concrete" for concrete strength and mix requirements.

1.3 REFERENCES

A. American Concrete Institute (ACI):

1. ACI 301 - Specification for Structural Concrete for Buildings.
2. ACI 302 IR - Recommended Practice for Concrete Floor and Slab Construction.
3. ACI 303.1 - Standard Specification for Cast-In-Place Architectural Concrete.
4. ACI 304 - Recommended Practice for Measuring, Mixing, Transporting and Placing of Concrete.
5. ACI 305R - Recommended Practice for Hot Weather Concreting.
6. ACI 306R - Recommended Practice for Cold Weather Concreting.
7. ACI 316 - Recommendations for Construction of Concrete Pavements and Bases.

B. American Society of Testing and Materials (ASTM):

1. ASTM C 494 -Standard Specification for Chemical Admixtures for Concrete.

1.4 SUBMITTALS

A. Product Data: Submit the manufacturer’s complete technical information sheets.

B. Design Mixes: For each type of concrete.

C. Samples for Initial Selection: Manufacturer's color charts showing full range of colors available.

D. Samples for Verification: Submit sample application for each special concrete finish required to verify selections made to demonstrate aesthetic effects.

E. Qualification Data: For color hardener manufacturer.

1.5 QUALITY ASSURANCE

A. Concrete Contractor Qualifications: Concrete work shall be performed by firm with three years experience and must have successfully completed not less than 6 projects work of similar scope and quality comparable in scale and complexity.

1. Statement of Contractor Qualifications: Submit list of at least 6 completed projects including project name, project address and owner contact information.

B. Obtain each specified material from same source and maintain high degree of consistency in workmanship throughout Project.

C. Colored Concrete Mockup:

1. Construct mockup using processes and techniques intended for use on permanent work, including curing procedures. Include samples of control, construction, and expansion joints in sample panels. Individual workers who will perform the work for the Project will produce mockup.
2. Obtain Architect's approval of mockup before proceeding with topping installation.
3. Accepted mockup provides visual standard for work of Section.
4. Mockup shall remain through completion of the work for use as a quality standard for finished work.
5. Remove mockup when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Products shall be delivered in original factory packaging, unopened and undamaged. Packaging will bear identification of product, manufacturer's identification and batch numbers. A technical information sheet and MSDS should be available for each product throughout the project.

B. Store the product in strict accordance with the manufacturer's recommendations in a location protected from damage, construction activity, and weather conditions.

1.7 JOB SITE CONDITIONS

A. Protection: Precautions shall be taken to protect surrounding areas and landscaping.

B. Schedule placement to minimize exposure to wind and hot sun

C. Avoid placement if rain, snow, or frost is forecast within a 24-hour period. Protect fresh concrete from moisture and freezing.

D. Comply with professional practices described in ACI 305R and ACI 306R.

1.8 PRE-JOB CONFERENCE

A. One week prior to placement of concrete a meeting shall be held to discuss the Project and application methods.

B. It is suggested that the Landscape Architect, General Contractor, Subcontractor, Ready-Mix Concrete Representative, and a Manufacturer's Representative be present.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Lithochrome Color Hardener dry-shake colored hardener by L.M. Schoefield or accepted substitution.

2.2 MATERIALS

A. Rock salt- sifted to remove all materials smaller than 1/8”.

B. Evaporation Retarder if needed shall be as follows:

1. BRICKFORM® Evaporation Retarder, Rafco Product’s factory concentrated surface retardant or accepted substitution.

2.3 COLORS

A. Colors as selected by Architect from manufacturer’s standard and custom colors. More than one color may be selected.

2.4 CONCRETE MIX DESIGN

A. Concrete shall be as specified in Division 03 Section "Cast-in-Place Concrete.

B. Slump of concrete shall be as specified in Division 03 Section "Cast-in-Place Concrete.

C. Do not add calcium chloride to mix as it causes mottling and surface discoloration.

D. Supplemental admixtures shall not be used unless approved by manufacturer.

E. Do not add water to the mix in the field.

PART 3 - EXECUTION

3.1 CONCRETE PLACEMENT

A. Move concrete into place with square-tipped shovels or concrete rakes.

B. Vibrators, when used, shall be inserted and withdrawn vertically.

C. Concrete shall be struck to specified level with wood or magnesium straight edge or mechanical vibrating screed.

D. The concrete surface shall be further leveled and consolidated with highway magnesium straight edge and/or magnesium bull float.

E. Mechanically float concrete surfaces as soon as concrete surface has taken its initial set and will support weight of a power float machine equipped with float shoes or combination blades and operator.

3.2 INSTALLATION – DRY-SHAKE COLORED HARDENER

A. Protect surrounding areas as specified.

B. Apply 2/3 of specified application rate to freshly floated concrete surface. Bleed water shall not be present during or following application of first and second shake.

C. Do not throw dry-shake; distribute evenly by hand or mechanical spreader designed to apply floor hardeners

D. As soon as dry-shake material has absorbed moisture, indicated by uniform darkening of surface, mechanically float concrete surface a second time, Using only a wood float, just enough to bring moisture from base slab through dry-shake color hardener.

E. Immediately following second floating, apply remaining 1/3 of specified application rate. If applied by hand, broadcast in opposite direction of first application for a more uniform coverage. If a mechanical spreader is used, apply the same manner as previously described.

F. As soon as dry-shake material has absorbed moisture, mechanically float concrete surface a third time using only a wood float.

G. Do not add water to the surface.

H. Do not use plastic sheeting to cure the concrete.

I. After the initial curing period, a clear, non-staining, non-yellowing curing compound that conforms to ASTM C 309 may be used.

3.3 APPLICATION OF ROCK SALT

A. Screed, tamp, and float concrete.

B. While concrete is still in a plastic stage, evenly dispense rock salt over surface at the rate of ten pounds per 150 square feet.

C. Carefully float the rock salt to depress it into concrete. Avoid covering rock salt.

D. Allow concrete to cure and set thoroughly under normal procedures.

E. After seven to ten days, thoroughly wash any remaining salt from the area. Do not contaminate any adjacent planting areas with salt.

3.4 PROTECTION OF FINISHED WORK

A. Provide final protection and maintain conditions, in a manner acceptable to Installer, that ensure topping are without damage or deterioration at the time of Substantial Completion.

B. Protect other work from staining or damage due to cleaning operations.

C. Prohibit foot or vehicular traffic on floor surface.

D. Barricade area to protect installation.

END OF SECTION 033519.13

SECTION 033533

STAMPED CONCRETE FINISHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes stamped finishing of concrete walk and drive areas.

1.2 SUBMITTALS

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

B. Design Mixtures: For each concrete mixture.

C. Samples: Submit samples of selected finish, approximately 18 by 18 by 2 inches thick, matching quality of finishes, colors, and textures indicated.

D. Material [**test reports**] [**certificates**].

1.3 MOCK-UPS

A. Construct mockups for each stamped pattern to verify selections made to demonstrate aesthetic effects. Build mockups to comply with the following requirements, using materials indicated for final Work.

1. Locate mockups on-site in the location indicated or, if not indicated, as directed by Architect, size 4 by 4 feet square.
2. Notify Architect one week in advance of the dates and times when mockups will be constructed.
3. Obtain Architect's approval of mockups before start of final unit of Work.
4. Retain and maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
5. Demolish and remove mockups from Project site at the time of Substantial Completion. Approved mockups in an undisturbed condition may become part of the completed Work.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Bomanite Corp. pattern stamp and color hardener or approved equal.

2.2 MATERIALS

A. Concrete materials and mix proportions are specified in Division 03 Section, “Cast-in-Place Concrete.”

B. Use other materials and accessories for the Work, including surface retarders when required to reproduce finish of design reference sample or mock-up.

C. Pattern and Color: As selected by Architect.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mix selected color into concrete per manufacturer's instructions.

B. Place and screed concrete as specified in Division 03 Section, "Cast-in-Place Concrete."

C. Apply color hardener as specified in Division 03 Section, "Special Concrete Finishes."

D. While concrete is still in plastic stage of set, apply imprinting tools to make the desired impression.

E. Repair damaged surfaces to match color, texture, and uniformity of surrounding surfaces.

END OF SECTION 033533

SECTION 03 38 00 – POST-TENSIONED CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections apply to this section.

B. Related work in other Sections related to Post-tensioned Concrete include:

1. Section 01 45 29 Structural Testing Laboratory Services.

2. Section 03 10 00 Concrete Forming and Accessories.

3. Section 03 20 00 Concrete Reinforcing.

4. Section 03 30 00 Cast-In-Place Concrete.

1.2 SCOPE OF WORK

A. The post-tensioning supplier and installer shall furnish all labor, materials, services and equipment required to produce a complete post-tensioned structural system. The work shall include the following items:

1. Furnishing all post-tensioning materials including prestressing steel, anchorages, wedges, pocket formers, couplers, plates, support bars, chairs, tendon enclosures, and bursting reinforcement.

2. Placing of all items listed above.

3. Performing all post-tensioning operations including stressing, anchoring, trimming, encapsulating tendon anchors, and grouting pockets.

4. Cooperating with the Owner's Testing Laboratory in their function of recording and reporting tendon elongation and tension applied to the prestressing steel.

5. Performing all engineering required to fully design a post-tensioning system that complies with the final force and tendon profiles as shown on the structural drawings and to prepare complete shop drawings and field placing drawings.

B. Tendons shall be unbonded as shown on the drawings.

1.3 ENVIRONMENTAL OBJECTIVES

A. The Owner has established environmental goals and strategies for achieving them for this project based upon the LEED® Green Building Rating System for New Construction & Major Renovations Version 2009, as developed by the U.S. Green Building Council. Refer to Division 01 Section "Sustainable Design Requirements."

B. Manufacturer to supply documentation of level of compliance or non-compliance with the following requirements before consideration as an "acceptable manufacturer:"

1. The following are mandatory requirements for the overall project:

   a. The material(s) in the product(s) supplied shall have a recycled content such that the sum of the post-consumer recycled content plus one-half of the pre-consumer content constitutes at least [Percentage of required recycled materials]% of the total value of the material in the project.
   b. [Percentage of close proximity material]% of the product(s) supplied is extracted, processed, and manufactured regionally within a radius of 500 miles of this project.

1.4 REFERENCE STANDARDS AND CODES

A. American Concrete Institute (ACI):

1. ACI 117 Specifications for Tolerances for Concrete Construction and Materials

2. ACI 301. – Specification for Structural Concrete

3. ACI 308.1 – Standard Specification for Curing Concrete

4. ACI 318. – Building Code Requirements for Structural Concrete and Commentary

B. Concrete Reinforcing Steel Institute (CRSI): “Manual of Standard Practice”, CRSI MSP-2.

C. Post-Tensioning Institute (PTI):

1. “Specification for Unbonded Single Strand Tendons”.

2. “Field Procedure Manual for Unbonded Single Strand Tendons”.

3. “Post-Tensioning Manual”.

D. Local Building Code.

1.5 SYSTEM DESCRIPTION

A. Unbonded post-tensioning system described herein is intended to perform without long-term corrosion or other distress in an aggressive environment as defined in the Specification for Unbonded Single-Strand Tendons. Post-tensioning strand, couplers, intermediate, and end anchorages shall be completely protected with a watertight, encapsulated system. Tendon sheathing and grease shall be as specified herein.

1.6 SUBMITTALS

A. Due to the interdependent nature of Sections “03 10 00 – Concrete Forming and Accessories”, “03 20 00 – Concrete Reinforcing”, “03 30 00 - Cast-In-Place Concrete” and “03 38 00 - Post-Tensioned Concrete,” the Contractor shall review all supplier’s shop drawings/field-placing drawings against each other and inform Architect/Engineer of any potential interferences or conflicts.

B. Drawings, Reports, Procedures : Submittals shall be submitted for review and approval and shall include but not be limited to the following:

1. Tendon layout, including dimensions, which locates the tendons in the horizontal plane. Detail horizontal curvature of tendons at block-outs, openings and anchorages, and show all openings in slabs and beams. Clearly designate each tendon.

2. Size and grade of tendon profiles showing support heights and locations, and any required reinforcing support steel. Show clearly the location of each tendon and the method of support. Coordinate the location of post-tension anchorages to eliminate conflicts with other embedded items such as curtain wall anchorages, or other similar type anchorages.

3. Value of the wobble and curvature coefficients and anchorage set used in the design to calculate the tendon elongation.

4. Details of reinforcement around stressing pockets, closures and openings, including bursting reinforcement, and any interference with tendons. Coordinate with mild reinforcing steel drawings as required.

5. Details of anchorages, the positive connection between the anchorage and sheathing, pocket formers, couplers, and other related hardware.

6. Details of the method for sealing the anchorage recesses after the tendon stressing tails have been removed.

7. Clearance requirements for the hydraulic equipment and the dimensions of any stressing pockets required.

8. Sequence of construction, including installation, pouring, jacking procedure, and stressing sequences. Show all construction joints and related tendon details.

9. Samples of forms to be used for field record of stressing operations.

10. Type and thickness of post-tensioning sheathing.

11. Type and chemical analysis of P-T coating showing compliance with Table 1 of the .“Specification for Unbonded Single Strand Tendons”.

12. Shop drawings shall be signed and sealed by a qualified professional engineer, licensed in the state of Texas who was in responsible charge of the drawing preparation.

C. Manufacturer's Data: Submit for review and approval.

1. Sample hardware, including but not limited to: Anchorage system, coated strand, wedges, pocket formers, and other sub-assemblies required for complete installation including all accessories required to complete the system. Submit valid Evaluation Service Report (ESR) from ICC Evaluation Service, Inc for each product.

2. Post-tensioning system brochures.

3. Complete post-tensioning procedure, including but not limited to: Stressing system, method of determining anchor force, method of determining tendon slack, and method of cutting off excess strand after anchorage.

4. Mill Certificates: Submit certified mill reports of post-tensioning steel immediately upon shipment indicating compliance with specified requirements for all material that is to be delivered to the project.

5. Equipment Calibration: Submit certification of the calibration of all ram and gauge sets to the Architect/Engineer as specified herein.

6. Certifications and other data as may be further required to demonstrate compliance with other items in this section.

D. Calculations:

1. Submit calculations showing all engineering required to fully design the post-tensioning system, including friction loss calculations, bursting reinforcement calculations, number of prestressing tendons, anchorage and coupling systems, tendon supports, and tendon stressing procedures, as required to fully comply with the final force and tendon profiles as shown on the structural drawings. The design shall be in accordance with the requirements of ACI 318. Submit tendon manufacturer's data that documents the wobble and curvature friction coefficients used in the friction loss calculations. Clearly show on the shop drawings the values of wobble and curvature coefficients used in the design.

2. Post-Tensioning Supplier shall secure the services of a qualified professional engineer, licensed in the state of Texas, to provide the design as specified above. Calculations shall be signed and sealed by the professional engineer and shall be submitted to Architect/Engineer for Owner's record only.

3. Review of shop drawings and calculations by the Architect/Engineer will not relieve the Post-Tensioning Supplier of responsibility for final design as specified herein.

4. By offering a proposal or entering into a contract for work of this Section, Post-Tensioning Supplier accepts the general design shown on the drawings as adequate for compliance with performance requirements at no additional cost to the Owner.

E. Stressing Records: The contractor shall provide the appropriate cooperation and access to the Owner's Testing Laboratory to allow them to measure, record, and clearly report the following information. In the absence of a Testing Laboratory representative, the post-tensioning installer shall measure, record, report and submit the information described below. Submit records to the Architect/Engineer for approval within 24 hours after stressing.

1. Floor, pour and tendon identification numbers. For walls, indicate wall location.Calculated elongation and actual measured elongation for each jacking point, and totals for each tendon.

2. Stressing ram number, initial and final gauge load reading during stressing for each tendon.

3. Date of stressing operation and signature of the Contractor's stressing personnel and inspector witnessing the operation.

4. Range of allowable elongations for jacking force or a measure of the deviation of the measured elongations from the calculated elongations. Deviations that do

not comply with the specified tolerances shall be noted for the Architect/Engineer to review.

5. Obvious irregularities or stress loss during anchoring procedures.

6. Required and actual concrete strength at time of jacking.

F. Record Drawings: The Contractor shall provide record drawings to the Owner, in care of the Architect/Engineer, of any approved changes from the contract documents. Form of record drawings may be legible marked-up prints of contract drawings, or separate drawings of same scale.

G. Review:

1. After review, shop drawings/field-placing drawings and data shall not be changed nor shall construction operations be deviated from, unless resubmitted under a cover letter delineating such change and reapproved.

2. Review of details and construction operations will not relieve the Contractor of his responsibility for completing the work successfully in accordance with the contract drawings and specifications.

H. LEED Submittals (Projects authorized for LEED certification only)

1. Recycled Content- Credit MR4.1/MR 4.2: Provide documentation indicating percentages of post-consumer and pre-consumer recycled content by weight per unit of product or assembly containing the product. Indicate the percentage of the dollar value of the recycled content compared to the total dollar value of the product or assembly containing the product.

2. Material Proximity- Credit MR 5.1/MR 5.2: Where the distance to the project site is 500 miles or less, indicate location and distance to project site of extraction, harvesting, recovery and manufacturing of all materials. Indicate the dollar value of the material cost of the product containing local/regional materials. Where product components are sourced or manufactured in separate locations, provide location and percentage by weight of each component per unit of product.

1.7 QUALITY ASSURANCE

A. Qualifications: The supply and installation of post-tensioning shall be executed by organizations that have successfully performed major work of a nature similar to that involved in this project for a minimum of five (5) years and have successfully completed a minimum of five (5) similar projects in own name, unless this requirement is waived by the Architect/Engineer prior to Contract award. The Contractor shall submit supporting evidence acceptable to the Architect/Engineer that this qualification has been met. Post-tensioning shall be performed using methods and related equipment that are in conformance with generally accepted systems of post-tensioning. Experienced individuals shall control and supervise all operations.

B. Fabrication Quality Assurance: The post-tensioning material shall be fabricated by a plant that is fully PTI-certified at the time of bidding, and that shall maintain this certification throughout the duration of this project as described in the Post-Tensioning Institute’s "Manual for Certification of Plants Producing Unbonded Single Strand Tendons."Installer Quality Assurance: All installers of unbonded post-tensioned tendons

shall be certified under the Post-Tensioning Institute's “Post-tensioning Certification Program of Field Personnel for Unbonded Post-tensioning Installers”.

C. Inspection and Testing: Inspection and testing shall be provided in accordance with the Structural Testing Laboratory Services Specification.

D. Source Quality Control:

1. If requested by the Architect/Engineer, take two (2) strand samples from one end of each coil at the fabrication plant prior to greasing and sheathing. The Post-Tensioning Supplier shall notify the Architect/Engineer when the coils are ready to be sampled.

2. Submit certified mill reports indicating compliance with ASTM A416, and if requested, the test data showing evidence of compliance with the Low Relaxation Strand requirement of ASTM A416, to the Architect/Engineer immediately upon shipment for all material delivered to the project. The mill report shall be based upon a minimum of two (2) tests for each reel, heat or lot, and shall include as a minimum the breaking load, modulus of elasticity, elongation at rupture, load at 1% extension, diameter and area of strand, standard chemical analysis and drawing mill.

3. Furnish all materials and handling which testing agency requires. Submit certification by the Post-Tensioning Supplier that any submitted samples are representative of the material to be furnished.

4. Package the post-tensioning strands at the supplier’s fabrication facility in a manner that prevents damage to strand and protects strand from moisture during transportation and storage.

E. Field Quality Control:

1. The Contractor shall maintain a consistent and good standard of workmanship. Check bulkheads, position of anchorages, tendon chairing and tying, location, size and placement of reinforcement, and tendon quantity.

2. Identify wedges and anchorages by individual concrete placement areas, floor sequence or both. Use materials only in their identified concrete placement areas. In the event materials intended for one concrete placement area are exchanged into another concrete placement area, notify architect/engineer and testing agency for tracking purposes.

3. Prior to pouring concrete, at a frequency as established for the project, an inspection of the tendons and mild reinforcing steel shall be made by the Architect/Engineer, or Independent Testing Agency. Placement of concrete shall not begin until acceptance of conditions is documented by the Architect/Engineer, or Independent Testing Agency.

4. Inspection of stressing operations shall also be performed as directed by the Architect/Structural Engineer.

5. The Contractor shall cooperate with the Owner’s Testing Laboratory in their efforts to record tendon elongations. The Contractor shall keep a copy of the stressing records with the shop drawings.

6. Submit certificates of all ram and gauge calibrations used on the project to the Architect/Engineer. Use of non-calibrated ram and gauge sets are not allowed on this project. If requested by the Architect/Engineer, Owner, or Field Inspector, the Contractor shall have the ram and gauge sets calibrated by an Independent Testing Agency, the cost of which shall be borne by the Contractor.

7. Manufacture and deliver tendons in sequence and quantity so as to avoid lengthy job site storage. Deliver tendons as close as practicable to the designated storage area to avoid excessive handling. Do not use chains or hooks to handle tendons.

8. Satisfactorily protect all prestressing steel from all moisture and rust or other physical damage prior to placement and keep steel free from deleterious substances, such as chlorides, fluorides, sulfites and nitrates. Provide protection for exposed prestressing steel beyond ends of members to prevent deterioration by rust or corrosion.

9. Do not store post-tensioning strand in such a manner that it is in direct contact with soil or fresh concrete or exposed to rain, snow, de-icing salts or other corrosive elements. Protect plastic materials planned to be stored for more than one month from exposure to sunlight.

10. Damage to tendon sheathing in excess of 2% of its length shall be grounds for rejection of sheathing.

11. Contractor shall inspect tendon sheathing for damage and to verify watertight seal between sheathing and anchor. Repair all damaged sheathing to the satisfaction of the Architect/Engineer.

PART 2 - PRODUCTS

2.1 POST-TENSIONING STEEL

A. Strand: Prestressing steel shall use strand conforming to ASTM A416, Low-Relaxation Type, and shall have a minimum guaranteed ultimate tensile strength of 270,000 psi based on the nominal area of the strand. The strand shall additionally conform to the “Specification for Unbonded Single Strand Tendons”. The strand shall be free of dirt, corrosion or injurious marks, scratches, seams, and sharp kinks. Surface rust shall be removed with a fine steel wool pad or by vigorous rubbing with a cloth. Pits on steel surface shall not exceed .002 in. in diameter or length. Oil-tempered strand is prohibited. Certified mill reports giving name of drawing mill shall be submitted.

B. Bar: Prestressing bars shall conform to ASTM A722, Type II-Deformed, and shall have a minimum ultimate tensile strength of 150 ksi.

C. Identification: All prestressing steel within every group or in the same member shall be of the same heat where practical. All tendons shall be assigned a proper heat and coil number and so identified on fabrication lists that are to be sent to the field with each shipment. Identify tendons in accordance with placing drawings. Unidentified steel shall not be allowed unless approved by the Architect/Engineer and tested.

D. Sheathing: All post-tensioning tendons shall be coated and sheathed with an approved slippage sheathing designed to prevent the intrusion of cement paste and the loss of the P-T coating material and be watertight and impermeable to water vapor over the entire

length. Such sheathing shall enclose the prestressing steel that shall then be placed in the forms prior to placement of concrete. The sheathing shall be continuously extruded polyethylene or polypropylene with a minimum density of 0.034 lb./in., a minimum thickness of 50 mils, and an inside diameter at least .03 inches greater than the maximum diameter of the strand. The sheathing shall not rupture due to normal temperature changes, coiling and field handling. The sheathing material shall be chemically stable, without embrittlement or softening over the anticipated exposure temperature range and service life of the structure. It shall be non-reactive with concrete, prestressing steel, reinforcing steel, and corrosion preventive P-T coating. Heat-sealed or plastic-wrapped sheathing is not acceptable.

E. P-T Coating: The corrosion preventive coating shall lubricate the tendon and permanently protect the prestressing steel against corrosion. It shall resist flow caused by gravity within the anticipated temperature range of exposure and provide non-brittle coating at the lowest anticipated temperature of exposure. It shall be chemically stable and non-reactive with prestressing steel, reinforcing steel, sheathing material, and concrete. The coating shall be applied under pressure to ensure the filling of the interstices between the individual wires of the strand. There shall be no voids or pockets between the sheathing and the coated strand for water or air to collect. The minimum amount of coating on the prestressing strand shall be 2.5 pounds of material per 100 feet of strand for a 0.5 inch diameter strand and 3.0 pounds per 100 feet for a 0.6 inch diameter strand. The P-T coating shall satisfy the requirements of table 1 of the ”Specification for Unbonded Single-Strand Tendons and Commentary”.

F. Repair tape: The tape used to repair damaged sections of sheathing or to wrap exposed strand shall be a minimum of 2 inches wide and shall be of a color that contrasts with the sheathing. The tape shall be self-adhesive and moisture-proof and shall be non-reactive with the sheathing, P-T coating, prestressing steel, or concrete.

2.2 MILD REINFORCEMENT

A. Refer to Specification Section 03 32 00 for requirements for mild reinforcement used as bursting reinforcement and tendon support.

2.3 ANCHORAGES AND COUPLERS

A. Performance and Specification:

1. Anchoring hardware shall be steel and shall meet the minimum requirements set forth in ACI 318, except as modified herein. The anchorage shall be capable of developing at least 95% of the minimum specified ultimate strength of the prestressing steel without exceeding anticipated set, and shall be capable of passing the static and dynamic tests as outlined in the PTI Post-Tensioning Manual. All anchorages, couplers, and miscellaneous hardware shall be the standard products as manufactured by the Post-Tensioning Supplier, unless shown otherwise, and shall be evaluated by the ICC Evaluation Service and be listed in a current Evaluation Service Report (ESR).

2. Anchors and couplers used shall include design features permitting a positive mechanical and watertight connection of the sheathing to the anchorage, and watertight closing of the wedge cavity, for stressing and non-stressing (fixed) anchorages. Friction connections between the anchor and the sheathing shall not be allowed. Intermediate stressing anchorages shall be designed to permit complete watertight encapsulation of the prestressing steel.

3. All anchorages shall have the demonstrated ability to remain watertight when subjected to a hydrostatic pressure of 1.25 psi over a period of 24 hours.

4. Sleeves used to connect the sheathing to the anchorages shall meet the same requirements as the sheathing for durability during fabrication, transportation, handling, storage and installation and have a minimum thickness of 50 mils. The overlap between the end of the extruded sheathing and the end of the sleeve and seal shall be a minimum of 4 inches. The sleeve shall be translucent or have another method to verify both that the P-T coating material is free of voids and the proper overlap with the sheathing.

B. Size: Anchorages and distribution (bearing) plates shall be sized according to ACI 318 unless certified test reports are submitted proving acceptable deviation. Bursting steel shall be designed by the Post-Tensioning Supplier consistent with the anchorage to be provided.

C. Anchorages at Construction Joints: 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 shall 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 ensure that the pocket is completely filled with concrete during subsequent pours.

D. Seating loss: Maximum allowable anchor slip or seating loss shall be 1/4 inch.

2.4 CONCRETE

A. The concrete shall have a minimum 28-day strength as specified on the drawings. Components or admixtures with chloride, fluoride, sulphite or nitrate ions or any other substance deleterious to prestressing steel shall not be used.

B. The chloride ion content of the concrete used in post-tensioned concrete contributed from the water, aggregate, cementitious materials and admixtures used in the mix shall not be greater than 0.06 percent by weight of cement.

C. See Section 03 30 00 Cast-In-Place Concrete for additional requirements for concrete.

2.5 TENDON SUPPORT SYSTEM

A. Slab Tendons: Support points shall consist of a bar support and continuous orthogonal steel as shown on the Contract Drawings. Bar supports shall be plastic, plastic tipped, epoxy coated or stainless steel.

B. Beam Tendons: Supports shall consist of reinforcing steel tied between stirrup legs as shown on the Contract Drawings.

C. For exterior exposure conditions, any supports that come in contact with the forming surface shall be plastic tipped stainless steel or high density plastic (grey in color).

2.6 PRE-CONSTRUCTION CONFERENCE

A. At least 30 days prior to post-tensioned concrete construction, the Contractor shall hold a meeting to review the detailed requirements for preparing the concrete design mixes and

to determine the procedures for producing proper post-tensioned concrete construction. Also review requirements for submittals, status of coordinating work and availability of materials. Establish work progress schedule and procedures for materials inspection, testing and certifications.

B. The Contractor shall require responsible representatives of every party who is concerned with the post-tensioned concrete work to attend the conference, including but not limited to the following:

Contractor's Superintendent
Laboratory responsible for the concrete design mix
Laboratory responsible for field quality control
Concrete Subcontractor
Post-Tensioning Supplier
Post-Tensioning and Mild-Reinforcement Installer
Ready-Mix Concrete Producer
Admixture Manufacturer(s)
Concrete Pumping Equipment Manufacturer
MEP Subcontractor
Owner's and Architect's/Engineer's Representative
Engineer-of-Record

C. Minutes of the meeting shall be recorded, typed and printed by the Contractor and distributed to all parties concerned within 5 days of the meeting. One copy of the minutes shall be transmitted to the following for information purposes:

Owner's Representative
Architect
Engineer-of-Record

D. The Contractor shall coordinate the scheduled date of the conference with the Architect/Engineer.

PART 3 - EXECUTION

3.1 POST-TENSIONING STEEL PLACEMENT

A. Profile: Post-tensioning tendons shall conform to the control points shown on the Contract Drawings and approved shop drawings and shall have a parabolic drape between supports unless noted otherwise. Harped tendons shall be straight between control points as shown on the drawings. Dimensions locating this profile apply to the center of gravity of the tendons. Low points of the tendons are at mid-span unless noted otherwise. Place the tendons normal to and concentric with anchorage plates. The transition curvature in tendon profile shall not start closer than 1 foot from end anchorages.

B. Interference: Slight deviation in spacing of the slab tendons is permitted where required to avoid openings and inserts that are specifically located. Horizontal sweeps to miss openings, inserts, etc. shall have minimum radius of 480 strand diameters. Where radius of curvature less than 480 diameters is necessary, contact the Architect/Engineer before moving those tendons. Coordinate the placement of mild steel reinforcement with placement of post-tensioning tendons. Proper tendon location has priority. Maintain sufficient concrete cover around tendons. Coordinate bursting steel requirements with details and post-tensioning subcontractor.

C. Tolerances: Firmly support tendons and anchorages to prevent displacement during subsequent operations. Place them with a vertical tolerance of plus or minus 1/4 inch in concrete members with depths of 8 inches or less, plus or minus 3/8 inch in concrete depths over 8 inches but less than 24 inches, and plus or minus 1/2 inch in concrete depths over 24 inches. In no case shall tendons violate the absolute minimum cover stated in ACI 117. Maintain a minimum clearance of 6 inches at all openings. Twisting or entwining of individual tendons within a bundle is not permitted.

D. Tendon Spacing: Maximum spacing of slab tendons shall be eight (8) times the thickness of the slab, but not greater than 54 inches, unless otherwise noted on the Contract Drawings. Bundle tendons in such a manner to allow proper concreting and the maintenance of the center of gravity of steel.

E. Supports: Provide a sufficient number of horizontal and vertical positioning supports to firmly support tendons to prevent displacement due to construction operations. Spacing of supports shall not exceed 4'-0" on center. Show all support devices on the shop drawings.

F. Welding: Welding of cross bars or any welding in the vicinity of the tendons is not allowed. Do not use post-tensioning tendons as an electrical ground for welding operations.

G. Sheathing

1. The sheathing shall be continuous from end to end of all stressing anchorages and all embedded dead ends including intermediate anchorages, unless shown otherwise on the Contract Drawings, or otherwise approved by the Architect/Engineer.

2. After installing the tendons and prior to concrete placement, inspect the sheathing on each tendon for its entire length to detect possible damage. Repair any detected tears or abrasions by procedures conforming to the "Field Procedures Manual for Unbonded Single Strand Tendons" by PTI. The repair of sheathing shall prevent intrusion of cement paste or loss of coating. The repair of sheathing shall also be watertight and approved by the Architect/Engineer.

H. Encapsulation: Complete the encapsulation of the post-tensioning system the same day as the tendons are installed.

I. Couplers: Do not use tendon couplers without prior approval of the Architect and Structural Engineer.

3.2 ANCHORAGES AND BLOCK-OUTS

A. Attachment

1. Attach anchorages securely to bulkhead forms using fasteners that will not corrode or are protected from corroding such that the anchor is perpendicular to the tendon axis.

2. Cover: Top, bottom, and edge concrete cover for anchorages shall be not less than the specified cover for reinforcement. Minimum concrete cover from the exterior edge of the concrete to wedge cavity area of anchor shall be 2 inches, unless otherwise noted on the drawings.

B. Bursting Reinforcement:

1. Provide and install bursting reinforcement behind anchorages as required by calculations subject to the following minimums:

a. Slab: Provide 2-#4 bars, one above and one below the tendon, continuous along concrete edges behind slab anchorages. Provide a #3 hairpin with 9" long legs around continuous #4's between each anchorage. Provide 2-#4 corner bars with 3'-6" legs, one each above and below the tendon center of gravity.
b. Beam: Provide 2-#4 bars, horizontal or vertical, with appropriate development length, behind all beam anchorages.

C. Block-outs and Pockets:

1. Adequately reinforce all block-outs or pockets required for anchorages so as to not decrease the strength of the structure.

2. Pocket formers used to provide a void form at anchorages shall be designed to prevent intrusion of concrete or cement slurry into the wedge cavity.

3. Do not coat block-out forms or pocket formers with grease, form oil, or any other substance that will decrease the bonding capacity of the patching grout to the surrounding concrete.

4. Install sleeves and seals connecting sheathing to anchorage to completely seal tendon against moisture infiltration.

3.3 CONCRETE PLACEMENT

A. Formwork: Design of the formwork shall take into account the possibility of the slab or girder lifting off the formwork during tensioning, thereby transferring the entire load to the support areas. Construct the formwork to permit movement of the member without damage during application of the post-tensioning force. Supporting forms in post-tensioned areas are not to be removed until concrete is fully stressed or as required by Section 03 10 00 whichever is later. The Contractor shall submit his proposed shoring and reshoring schemes prior to commencement of forming work.

B. Construction Joints: Locate construction joints at or near where the center-of-gravity of the strands coincides with the center-of-gravity of the concrete section unless otherwise approved by the Architect/Engineer. The contractor shall submit construction joint locations in post-tensioned members to the Architect/Engineer for approval.

C. Inserts, Anchors, and Coring: All inserts and anchors for suspended mechanical and architectural work shall be cast-in-place wherever feasible. Additional fasteners will be permitted 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 identify tendon locations on the surface of the slab if drilling or coring is to be done after concrete is placed.

D. Placement: Place the concrete in conformance with the requirements of the Specifications. Do not place the concrete until the Architect/Engineer, or Independent Testing Laboratory has inspected the placement of the mild steel reinforcement and tendons at the frequency established for the project. Place the concrete in such a manner as to ensure that alignment of post-tensioning tendons remains unchanged.

Make special provisions to ensure proper vibration of the concrete around the anchorage plates. When concrete is distributed across an area being poured y way of horizontally supported slick-tube and/or rubber pump hose, the slick-tube and/or rubber hose shall be supported in such a way that does not contact the reinforcing steel or post-tensioning tendons. The slick-tube and/or rubber hose shall be braced to prevent surging of the lines that could dislodge the reinforcing and/or tendon locations. Monitor the tendon positioning during the concrete placement. All floors below the level that is to have concrete placement shall have been stressed before this concrete is placed, unless the shoring has been designed for the ensuing loads.

E. Openings: Openings shall not be cut into cast concrete without the approval of the Architect/Engineer.

3.4 STRESSING

A. Methods: Perform post-tensioning by methods and related equipment that are in conformance with generally accepted systems of post-tensioning. Variations of such generally accepted methods and equipment will be permitted with Architect/Engineer approval, provided equal results can be obtained.

B. Concrete Strength: Do not begin the post-tensioning operations until tests or readings have indicated that the concrete in the members has attained a compressive strength that is adequate for the requirements of the anchorages but not less than 3000 psi unless otherwise specified on the Contract Drawings. See Concrete Formwork section 03 10 00 for acceptable methods for determining *in situ* concrete strengths.

C. Equipment: Stress all tendons by means of hydraulic rams, equipped with accurate reading hydraulic pressure gauges that have been individually calibrated with a particular ram to permit the stress in the prestressing steel to be computed at any time. A certified calibration curve shall accompany each ram and gauge set. Immediately recalibrate the ram and gauge set if inconsistencies between the measured elongation and the gauge reading occur.

D. Forces: Anchor the prestressing steel at an initial or anchor force that will result in the ultimate retention of the working or effective force shown on the plans. Jacking forces shall be those indicated on the shop drawings. The length of a tendon pull more than that shown by the required friction calculations or more than 125 feet for a one-way pull or 250 feet for a two-way pull is not permitted unless it is justified by calculations and specifically approved by the Architect/Engineer. The Field Inspector shall verify the wobble and curvature friction coefficients during the stressing operation and shall report to the Post-Tensioning Engineer deviations greater than 10% from the values assumed in the design. Required adjustments to the stressing operation shall be recommended by the Post-Tensioning Engineer and approved by the Architect/Engineer.

E. Elongations: Keep records of all tendon elongations as previously described in this Section. Agreement within 7% between the gauge reading and the measured elongation and between the measured and the calculated elongation after stressing will be considered satisfactory. Deviations greater than 7% will be reported to the Architect/Engineer prior to completing stressing operation. No tensioning will be permitted until it is demonstrated that the prestressing steel is reasonably free and unbonded in the enclosure. Evidence that the steel is unbonded will be considered satisfactory if inward movement of steel is observed at one end of the tendon when a nominal pull is applied to the steel at the other end. The Architect/Engineer may order a force/elongation check at any time. Do not cut off tendons until elongation records have been reviewed and approved in writing by the Architect/Engineer.

F. Stressing Sequence: The stressing sequence shall be as shown on the approved shop drawings. Use the following general stressing sequence except as otherwise noted or approved by the Architect/Engineer.

1. Beam and Slab:
   Step #1. Stress temperature tendons, if applicable.
   Step #2. Stress continuous uniform slab tendons.
   Step #3. Stress added uniform slab tendons.
   Step #4. Stress continuous beam tendons.
   Step #5. Stress added beam tendons.
   Step #6. Stress girder tendons, if applicable.

G. Safety: Precautions shall be taken to prevent workers from standing directly behind, above or in front of the stressing rams.

H. Broken Tendons: The total loss of prestressing force in any post-tensioned concrete member due to unreplaced broken tendons shall not exceed 2% of the total prestressing force, unless otherwise accepted by the Architect/Engineer.

3.5 GROUTING ANCHORAGE RECESSES

A. Cut the tendon tails within 24 hours after the stressing records have been approved. Cut off the excess strand at least 1/2 inch inside the face of the finished concrete surface, and not more than 3/4 inch from the face of the anchorage. Cutting may be done by means of abrasive wheel, hydraulic shears, or, to prevent heating of the wedges, oxy-gasoline cutting flame is permitted. Do not allow the wedges to become heated.

B. Cover the end of tendon with approved coating-filled encapsulation cap, or other approved method no more than 24 hours after the tendon tails have been cut to ensure encapsulation of the exposed tendon.

C. Coat the anchorage recesses with an approved bonding agent and fill flush with a non-shrink, non-stain, chloride free grout compatible for use with prestressing steel or approved equal in accordance with manufacturer’s recommendations. Do not allow contamination of the anchorage recess surface that reduces the bonding capacity of the non-shrink grout.

3.6 INSTALLATION SUPERVISION

A. The duties of the post-tensioning installer's supervisor shall include:

1. Check tendon placement before and during pouring of concrete. Be present during pours and check for tendons being moved out of position.

2. Mark tendons prior to stressing and verify with the Owner’s Testing Laboratory that all initial marks are accurate.

3. Observe that tendon elongation measurements are made and recorded by Testing Laboratory or, in the absence of a Testing Laboratory representative, measure, record and report tendon elongations after stressing and submit copy of original to Architect/Engineer.

4. Compare results of actual tendon elongations with hydraulic ram gage reading and with calculated elongation.

5. Require checking of tendon force and/or elongation if requested by the Architect/Engineer.

6. Do not allow cutting off of tendons without the Architect/Engineer's written approval.

3.7 QUALITY ASSURANCE TESTING AND INSPECTION DURING CONSTRUCTION

A. See Testing Laboratory Services section of these Specifications for post-tensioning inspection and test requirements.

END OF SECTION 03 38 00

SECTION 03 41 00– STRUCTURAL PRECAST CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 01 - Specification sections, apply to work of this section.

1.2 SCOPE OF WORK

A. Provide labor, material and equipment to produce, deliver and erect double tees, beams, columns, wall panels, slabs, hollow-core planks, stair units and other members and materials necessary to complete the structure as described by the Drawings, General Notes and these Specifications.

1.3 QUALITY ASSURANCE

A. Applicable Standards:

1. American Concrete Institute (ACI):

301	Specifications for Structural Concrete for Buildings
318	Building Code Requirements for Reinforced Concrete

2. Prestressed Concrete Institute (PCI)

MNL-116	Manual for Quality Control for Plants and Production of Structural Precast Concrete Products
MNL-117	Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products
MNL-120	PCI Design Handbook, Precast and Prestressed Concrete
MNL-135	Tolerance Manual for Precast and Prestressed Concrete Construction

3. Concrete Reinforcing Steel Institute (CRSI): Manual of Standard Practice.

4. American Welding Society (AWS):

D1.1	Structural Welding Code-Steel
D1.4	Structural Welding Code-Reinforcing Steel

5. Local building code, with supplements.

B. Fabricator Qualifications:

1. The precast concrete producer shall not have less than 5 years experience in providing structural precast and/or precast prestressed concrete products and services normally associated with the industry.

2. The precast concrete producer shall be a participant in the PCI Plant Certification Program and, upon request, shall submit written evidence to show experience, qualifications and adequacy of plant capability and facilities for performance of

contract requirements. Compliance with this provision is subject to verification by the Architect and Engineer.

C. Erector Qualifications: The precast concrete erector shall not have less than 2 years experience in the erection of precast structural concrete similar to the requirements of this project. Upon request, provide written evidence that equipment and personnel are adequate and qualified for performance of contract requirements.

D. Welder and Welding Machine Operator Qualifications: All field and plant welders shall be certified in accordance with AWS D1.1 for the type of welding required.

E. Plant Quality Control: Provide copies of plant quality control program describing procedures for the following:

1. Verifying size and placement of reinforcing steel and prestressing strand.

2. Verifying strength of concrete.

3. Tensioning and de-tensioning operations.

4. Verifying sizes and critical dimensions of members.

5. Verifying position of plates, inserts and other embedded items.

6. Verifying squareness of forms and positioning of blockouts.

7. Final inspecting of products prior to shipment.

If units are produced at locations other than precast concrete production plants, maintain procedures and conditions for quality control that are equivalent to plant production.

F. Professional Engineer: A professional engineer who is licensed to practice engineering in the state the project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for projects with precast concrete framing that are similar to that indicated for this Project in material, design, and extent.

1.4 DELIVERY, STORAGE AND HANDLING

A. Store precast concrete units at manufacturer's plant or project site to prevent cracking, distortion, staining, or other physical damage, and so that markings are visible. Lift and support units at designated lift points. Do not use upper member of stacked tier as storage area for shorter member or heavy equipment. Deliver units to project site in such quantities and at such times to assure continuity of installation.

1.5 SUBMITTALS

A. Certification and Test Reports: Submit manufacturer's specifications and instructions for manufactured materials and products. Include manufacturer's and plant's certifications and laboratory test reports for the following:

1. PCI Plant Certification.

2. Concrete mix designs, including sources of coarse, fine and lightweight aggregates as well as admixtures.

3. Prestressing strand mill certificates.

4. Mill certificates for reinforcing bars and welded wire mesh.

5. Mill certificates for high strength reinforcing bars.

6. Structural steel mill certificates.

7. Welder and welding operator certifications.

8. Calibrations of prestressing jacks.

9. Calibration of cylinder testing machine.

10. Mill certificates for cement.

11. Cylinder test reports on concrete for all precast units.

B. Shop Drawings: Submit for review by the Architect and Engineer detailed shop drawings as follows:

1. Erection Drawings:

   a. Column anchor bolt setting plan and plan of other miscellaneous items to be embedded in cast-in-place concrete for the attachment of precast concrete members.
   b. Dimensioned building plans, elevations and sections showing identification of each precast member. Drawings submitted shall not be reproducibles of the contract drawings.
   c. Complete connection details showing size, type and grade of all plates, inserts and anchors. Show proper welding symbols in accordance with AWS D1.1.
   d. Description of all loose and cast-in hardware, plates, inserts, etc.
   e. Field installed anchor location drawings.
   f. Erection sequence and handling requirements.
   g. All dead, live and other applicable loads used in the design.

2. Production Drawings for all precast members:

   a. Member elevations and sections showing all dimensions.
   b. Finishes.
   c. Size, type, grade and location of all reinforcing steel including that required for handling and erection.
   d. Prestress forces and number of strands.
   e. Concrete strengths at release for prestressed members and 28 day design strength.
   f. Size, type and location of all cast-in plates, inserts and other hardware.
   g. Size, type and location of all expansion blockouts.
   h. Size, type and location of all lifting and handling devices.
   i. Estimated cambers at time of erection.
   j. Estimated member weights.
   k. Method of transportation.

3. All shop drawings submitted shall be sealed by a professional engineer who is licensed in the state where the project is located.

C. Design Calculations:

1. Precast Unit Design: Provide for review by the Engineer complete design calculations for dead loads, live loads, lateral loads, and lifting and erection loads. Calculations shall show design for all connections at the member ends and to each adjoining member.

2. Details shown on the contract drawings shall be considered minimum requirements that shall be increased or modified as required for actual design forces. Refer to General Notes on the structural drawings for design loads.

3. Calculations shall be prepared by or under the direct supervision of a professional engineer. All members designed by computer shall have calculations that include documentation of the computer program identifying the method of solution, all input data and output for each unit. At least one unit shall be correspondingly designed by hand and submitted with the computer data for verification. All calculations shall be neat, well organized and bound. Partial, incomplete or unstamped calculations will be rejected.

4. Precast Erection Design: The Erector shall submit installation drawings and engineering calculations of the erection process stamped by a professional engineer licensed in the state where the project is located for Engineer review.

5. Design Modifications: Design modifications may be made as necessary to meet field conditions and to ensure proper fitting of the work, but only with the prior written approval of the Architect and Engineer for each occurrence. Provide complete design calculations and drawings for required or anticipated design modifications in accordance with these specifications.

D. Samples

1. Submit all samples of materials as requested by the Architect and specified herein in accordance with requirements of the Division 01, General Requirements and obtain written approval from the Architect before ordering materials.

2. Finish samples: Submit two 12”x12”x2” thick samples of concrete to indicate color, texture, and finish for approval.

3. Prepare two full-size samples of a structural precast concrete bay unit for Architect’s inspection at production plant prior to start of installation work, and after Architect’s review of finish samples. Acceptable full-size samples may be incorporated in job installation as follows.

   a. One approved full-size unit shall be identified and installed in the project for the purpose of judging the installed units. One approved full-size unit shall be retained at the production plant for the precast producer to judge completed units prior to shipment. The full-size unit retained at the production plant may be the last unit incorporated into the project.

4. Submit samples of anchors, dowels, and bearing pads and all other materials requested by the Architect.

PART 2 - PRODUCTS

2.1 FORMWORK

A. Provide forms and, where required, form facing materials of metal, plastic, wood, or other acceptable material that is non-reactive with concrete and will produce required finished surfaces. Rust-stained or excessively worn forms that would impair the quality of the finished surface are not acceptable. Comply with recommendations set forth in ACI 347, Guide to Formwork for Concrete.

B. Accurately construct forms mortar-tight and of sufficient strength to withstand pressures due to concrete placing operations, temperature changes, and when prestressed, the pretensioning and detensioning operations. Maintain formwork to provide completed precast concrete units of shapes, lines, and dimensions indicated on the approved shop drawings within specified production tolerances.

C. Unless forms for plant-produced prestressed concrete units are stripped prior to detensioning, design forms so that stresses are not induced from precast units due to deformation of concrete under prestress or to movement during detensioning.

2.2 REINFORCING MATERIALS

A. Reinforcing Bars: ASTM A615, Grade 60. All reinforcing steel that requires welding shall conform to ASTM A 706.

B. Galvanized Reinforcing Bars: ASTM A767, Class II (2.0 oz. Zinc P.S.F.).

C. Epoxy Coated Reinforcing Bars: ASTM A775.

D. Plain Steel Wire: ASTM A82.

E. Welded Wire Fabric: ASTM A185.

F. Deformed Steel Wire: ASTM A496.

G. Welded Deformed Steel Wire Fabric: ASTM A497.

H. Prestressing Tendons: ASTM A 416/A 416M, Grade 250 (Grade 1720) or Grade 270 (Grade 1860), uncoated, 7-wire, low-relaxation strand or ASTM A 886/A 886M, Grade 270 (Grade 1860), indented, 7-wire, low-relaxation strand (including supplement).

I. Unbonded Post-tensioning Strand: ASTM A 416/A 416M with corrosion inhibitor conforming to ASTM D 1743, Grade 270 (Grade 1860), 7-wire, low-relaxation strand with polypropylene conduit sheath.

J. Prestressing Bars: ASTM A722.

K. Supports for Reinforcement:

1. Provide supports for reinforcement including bolsters, chairs, spacers and other devices for spacing, supporting or fastening reinforcing, complying with CRSI recommendations.

2. For exposed-to-view concrete surfaces where legs of supports are in contact with forms, provide supports with legs that are either plastic protected or all plastic (CRSI Class 1) or stainless steel protected (CRSI Class 2).

2.3 CONCRETE MATERIALS

A. Refer to the drawings for classes and strengths of concrete required.

B. Portland Cement: ASTM C150, Type I or Type III, or as otherwise specified on the drawings. For concrete exposed to salt air or salt water, provide type II or type V cement.

1. Concrete exposed to sulfates in soil or water

a. Exposure class S1: For areas designated on the drawings as exposure class S1, use ASTM C 150, Type II or ASTM C 1157, Type MS.
b. Exposure class S2: For areas designated on the drawings as exposure class S2, use ASTM C 150, Type V or ASTM C 1157, Type HS.
c. Alternate cement types for exposure classes and S2: ASTM C 150, Type I or III cement may be used for concrete exposed to exposure S1 or S2 if the tricalcium aluminate (C3A) content is less than 8 percent for S1 exposure or 5 percent for S2 exposure ASTM C 150, Type I or III cement may be used for exposure to seawater if the tricalcium aluminate content does not exceed 10 percent and the w/cm ratio of the concrete mix does not exceed 0.40.
d. Exposure class S3: For areas designated on the drawings as exposure class S3, use ASTM C 150, Type V plus pozzolan or slag or ASTM C 1157, Type HS plus pozzolan or slag or ASTM C 595, Type IP (HS) or Type IS (HS). The amount of pozzolan or slag added or in a blended mix shall be such that has been determined by service record to improve sulfate resistance when used with Type V cement or the amount that when tested according to ASTM C 1012 meets the criteria of table 4.5.1 in ACI 318-08.
e.

2. Use only one brand and type of cement throughout the project, unless otherwise acceptable to the Architect and Engineer.

C. Supplemental Cementitious Material:

1. Fly Ash: C 618, Class C or F.

2. Metakaolin: ASTM C 618, Class N.

3. Silica Fume: ASTM C 1240 with optional chemical and physical requirements.

4. Slag Cement: ASTM C 989, Grade 100 or 120.

D. Aggregates:

1. Gravel or crushed stone: ASTM C33. Provide from a single source for exposed concrete.

2. Lightweight aggregate: expanded shale or clay, ASTM C330.

Provide lightweight concrete with a dry unit weight of not less than 110 nor more than 116 pounds per cubic foot. Design the mix to produce strengths as

indicated on the drawings with a split cylinder strength factor ($f_{ct}/(f'_c)^{0.5}$) of not less than 5.7 and a drying shrinkage limit of 0.03% at 28 days.

E. Water: Comply with the requirements of ASTM C1602.

F. Calcium Chloride; not permitted

G. Air-Entraining Admixture: ASTM C260. Provide air entrainment as specified in Table 4.2.1.of ACI 318 in all concrete exposed to freezing and thawing. Interior steel troweled surfaces subjected to vehicular traffic shall not have more than 3% entrained air. Surfaces scheduled to receive hardeners shall not have more than 3% entrained air.

Subject to compliance with requirements, provide one of the following products and manufacturers:

"Darex" or "Daravair" series; W. R. Grace & Co.
"MBAE90" or "Micro-Air"; BASF Admixtures, Inc
"Sika AER"; Sika Corporation
"Air Mix" or "AEA-92"; The Euclid Chemical Company, Inc.
“Eucon Air 30” or “Eucon Air 40”, The Euclid Chemical Co., Inc.

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

H. Water-Reducing Admixture: ASTM C494, Type A. See maximum permissible chloride ion content in concrete specified below.

Subject to compliance with requirements, provide one of the following products and manufacturers:

"Pozzolith 322N" or "Polyheed 997"; BASF Admixtures, Inc.
"Plastocrete 161"; Sika Chemical Corp.
"Eucon WR-75 or WR-91"; The Euclid Chemical Company, Inc.
"WRDA ";series W.R. Grace & Co.
“Eucon NW” or “Eucon LW”, The Euclid Chemical Company, Inc.

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

I. Mid-Range Water-Reducing Admixture: ASTM C494, Type A and Type F. See maximum permissible chloride ion content in concrete specified below.

Subject to compliance with requirements, provide one of the following products and manufacturers:

“Polyheed 997”, BASF Admixtures, Inc.
“Eucon MR”, The Euclid Chemical Company, Inc.
“Sikament HP”, Sika Chemical Corp.
“Daracem” or “Mira ” series, W.R. Grace & Co.
“Eucon X15” or “Eucon X20”, The Euclid Chemical Company, Inc.

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

J. High-Range Water-Reducing Admixture (Superplasticizer): ASTM C494, Type F or Type G. See maximum permissible chloride ion content in concrete specified below.

Subject to compliance with requirements, provide one of the following products and manufacturers:

"ADVA" or "Daracem" Series; W.R. Grace & Co.
"Rheobuild 1000" or "Glenium 30/30"; BASF Admixtures, Inc.
"Sikament"; Sika Chemical Corp.
"Eucon 37/1037" or "Plastol" series; The Euclid Chemical Company, Inc.
"Euconl SP" or "Eucon RD", The Euclid Chemical Company, Inc.

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

K. Water-Reducing, Accelerator Admixture (Non-Corrosive, Non-Chloride): ASTM C494, Type C or E. See maximum permissible chloride ion content in concrete specified below.

Subject to compliance with requirements, provide one of the following products and manufacturers:

"Polarset";"Gilco", "Lubricon NCA" or "DCI", W.R. Grace & Co.
"Pozzutec 20+"; BASF Admixtures, Inc.
"Accelguard 80/90"; "NCA", or "AcN", The Euclid Chemical Company, Inc.
"Plastocrete 161FL", Sika Chemical Co.
"Eucon AcN", The Euclid Chemical Company, Inc.

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

L. Water-Reducing, Retarding Admixture: ASTM C 494, Type D. See maximum permissible chloride ion content in concrete specified below.

Subject to compliance with requirements, provide one of the following products and manufacturers:

"Daratard" series, W.R. Grace & Co.
"Pozzolith 100XR" or "Pozzolith 300R; BASF Admixtures, Inc.
"Plastiment"; Sika Chemical Co.
"Eucon Retarder", Series, The Euclid Chemical Company, Inc.

Submit manufacturer's certification that product conforms to the requirements specified and is compatible with all other admixtures to be used.

M. Viscosity Modifying Admixture: Used to enhance plastic concrete properties such as workability, pumpability, and stability for "self-consolidating concrete".

"Rheomac VMA" series, BASF Building Systems
"Eucon SL" or "Visctrol", The Euclid Chemical Co.
"VisoCrete" series, Sika Chemical Co.
"VMAR" series, W.R. Grace & Co.

2.4 CONNECTION MATERIALS

A. Steel Plates: ASTM A36.

B. Steel Shapes: ASTM A36.

C. Carbon-Steel Bolts and Studs: ASTM A 307, Grade A or C, carbon-steel, hex-head bolts and studs; carbon-steel nuts, ASTM A 563; and flat, unhardened steel washers, ASTM F 844.

D. Anchor Bolts: Non-headed type with tensile strength requirements conforming to [ASTM F1554 Grade 36] or [ASTM A 307], unless otherwise indicated. Provide regular hexagon nuts and carbon steel washers.

E. Stainless-Steel Plate: ASTM A 666, Type 304, of grade suitable for application.

F. Stainless-Steel Bolts and Studs: ASTM F 593, alloy 304 or 316, hex-head bolts and studs; stainless-steel nuts; and flat, stainless-steel washers.

1. Lubricate threaded parts of stainless steel bolts with an anti-seize thread lubricant during assembly.

G. Stainless-Steel Headed Studs: ASTM A 276, with minimum mechanical properties for studs as indicated under MNL-116, Table 3.2.3.

H. Weldable Reinforcing Bars: ASTM A706.

I. Headed Studs: ASTM A108, 60,000 psi minimum tensile strength.

J. Deformed Bar Anchors: ASTM A496, 70,000 psi minimum yield strength.

K. Prestressing Steel Bars: ASTM A722.

Approved Manufacturer: Dywidag Systems International, USA, Inc.

L. Threaded Rods: ASTM A36.

M. Welding Electrodes: Comply with AWS D1.1.

N. Ductile Iron Inserts: ASTM A536.

Approved Manufacturers:

1. Dayton/Richmond Concrete Accessories.

2. Hohmann & Barnard, Inc.

O. Ferrule Wing Inserts: Provide from the following products:

1. “FX-19 Ferrule Wing Insert”, Meadow Burke Products.

2. “F-62, Flared Thin Slab Ferrule Insert”, Dayton/Richmond Concrete Accessories.

P. Corrosion Protection of Steel Units: All items shall be hot-dipped galvanized in accordance with ASTM A153. Zinc-rich coating for field repair shall be manufactured by Sherwin-Williams (Zinc-Clad 5 B69 A 45) or ZRC Cold Galvanizing Compound.

2.5 GROUT MATERIALS

A. Non-Metallic Non-Shrink Grout: Premixed, non-corrosive, non-staining product containing Portland cement, silica sands, shrinkage compensating agents, and fluidity improving compounds. Conform to ASTM C1107. Provide the minimum strength as shown below as determined by grout cube test at 28 days.

B. Attain 28 day compressive strength as determined by grout cube tests conforming to ASTM C109 adequate to transfer the design bearing stresses to the supporting concrete. Unless shown otherwise by the precaster's engineering calculations, the required minimum compressive strength shall be as follows:

1. 6,000 psi for supporting concrete up to 3,000 psi.

2. 8,000 psi for supporting concrete between 3,000 psi and 4,000 psi.

3. Unless noted otherwise on the drawings, grout strength on supporting concrete greater than 4000 psi shall be 8000 psi.

C. Follow manufacturer's directions and recommendations for mixing and placing grout.

D. Grout to be similar in color to that of surrounding concrete.

E. Acceptable non-shrink grouts:

"Sonogrout 10k" as manufactured by Sonneborn-ChemRex, Inc.
"Crystex" and "Duragrout" as manufactured by L&M Construction Chemicals, Inc.
"Sure Grip High Performance Grout," and "1107 Advantage Grout" as manufactured by Dayton-Superior Corporation.
"Masterflow 713", and "Set Grout" as manufactured by Master Builders Technologies.
"Five Star Grout" as manufactured by U.S. Grout Corp.
"NS Grout" as manufactured by The Euclid Chemical Company.
"SikaGrout 212", as manufactured by Sika

F. Sand Cement Grout: Provide sand cement grout for grouting all pockets and blockouts in precast members and in grouting prestressed ducts where specified on the drawings. Sand cement grout shall consist of Portland Cement (ASTM C 150 Type I or III), sand (ASTM C33), and water. Proportions by weight shall be one part cement, 2 1/4 to 2 1/2 parts sand, and the minimum amount of water required to obtain a workable mix. Minimum compressive strength shall be 3500 PSI at 28 days. Admixtures to accelerate the set or prevent freezing may be utilized, except the use of admixtures containing chlorides will not be permitted.

2.6 BEARING PADS

A. Elastomeric Pads:

1. Unreinforced: AASHTO M 251, plain, vulcanized, 100 percent polychloroprene (neoprene) elastomer, molded to size or cut from a molded sheet, 50 to 70 Shore A durometer according to ASTM D 2240, minimum tensile strength 2250 psi (15.5 MPa) per ASTM D 412 and having a minimum thickness of 3/8" for tees, 1/2" for

beams and 1/4" for slabs, unless otherwise shown on the drawings. Pads greater than 1 1/4" in thickness shall be laminated with steel plates (min. 1/16" thick) molded into the material.

2. Random-Oriented, Fiber-Reinforced Elastomeric Pads: Preformed, randomly oriented synthetic fibers set in elastomer. Surface hardness of 70 to 90 Shore A durometer. Capable of supporting a compressive stress of 3000 psi (20.7 MPa) with no cracking, splitting or delaminating in the internal portions of the pad. Test one specimen for each 200 pads used in the Project.

3. Cotton-Duck-Fabric-Reinforced Elastomeric Pads: Preformed, horizontally layered cotton-duck fabric bonded to an elastomer. Surface hardness of 80 to 100 Shore A durometer. Conforming to Division II, Section 18.10.2 of AASHTO Standard Specifications for Highway Bridges, or Military Specification, MIL-C-882E.

4. Design: Design of bearing pads shall conform to the design recommendations in the PCI Design Handbook.

5. Size pads so that both surfaces are in complete contact with the bearing pads. The design bearing pressure for unreinforced bearing pads shall not exceed 800 psi under total service load, and 500 psi under dead load, unless shown otherwise by approved manufacture's data.

6. Provide beveled, plain elastomeric bearing pads between non-parallel load surfaces.

B. High-Density Plastic: Multimonomer, nonleaching, plastic strip capable of supporting construction loads with no visible overall expansion.

C. Tetrafluoroethylene (TFE) Slide Bearings:

1. Glass-filled virgin Teflon slide bearings as shown on the drawings and as manufactured by:

a. Con-Serv, Inc., Georgetown, SC
b. Seismic Energy Co., Athens, TX

Other manufacturers will be acceptable only with Engineer approval.

2.7 EPOXY MORTAR PATCH

A. General Requirements: Two-component material suitable for use on dry or damp surface, complying with ASTM C881, for use in concrete repairs. The color of the patch shall match the surface color of the precast concrete unit.

B. Products for Epoxy Mortar Patches:

"Sikadur Lo-Mod LV"; Sika Chemical Corporation
"Duracrete", The Euclid Chemical Company
"Sure Level Epoxy (J-57)", Dayton-Superior
"Epofil", BASF Building Systems
"Pro-Poxy 2500", Unitex
"Rezi-Weld 1000", W. R. Meadows
"US Spec EPM 3000", US Mix Co.
"Duralcrete LV", The Euclid Chemical Company

"SpecPoxy Binder", SpecChem

2.8 GROUT DUCTS IN PRECAST WALL PANELS

A. Ducts for prestressed bars shall be flexible metal conduit with a diameter at least 1/4" larger than the nominal diameter of the bar and a minimum wall thickness of 0.040" (20 gage). The metal conduit shall be capable of withstanding a crushing force of 600 pounds per lineal foot and shall be completely sealed against the leakage of grout.

2.9 INSULATED PANEL ACCESSORIES

A. Expanded Polystyrene Board Insulation: Rigid, cellular polystyrene thermal insulation complying with ASTM C578 formed by expansion of polystyrene base resin.

B. Extruded-Polystyrene Board Insulation: Rigid, cellular polystyrene thermal insulation complying with ASTM C 578 formed from polystyrene base resin by an extrusion process using HCFCs as blowing agents.

C. Polyisocyanurate Board Insulation: Rigid, cellular polyisocyanurate thermal insulation complying with ASTM C 591 formed by using HCFCs as blowing agents.

D. Wythe Connectors: Provide connectors manufactured to connect wythes of precast concrete panels of the following types:

1. Glass-fiber
2. Vinyl-ester polymer
3. Polypropylen pin
4. Stainless-steel pin
5. Bent galvanized reinforcing bars
6. Galvanized welded wire truss
7. Galvanized bent wire
8. Cylindrical metal sleeve anchor

PART 3 - EXECUTION

3.1 PRODUCTION

A. General: Produce precast concrete units complying with manufacturing and testing procedures, quality control recommendations and dimensional tolerances of PCI MNL-116, MNL-117 and MNL-135, unless stricter requirements are specified herein or on the drawings.

B. Proportioning and Design of Mixes:

1. Prepare design mixes for each type of concrete required.

2. Design mixes may be prepared by an independent testing facility or by qualified precast manufacturing personnel, at precast manufacturer's option.

3. Proportion mixes by either laboratory trial mixture or field experience methods, complying with ACI 301 and ACI 318, using materials to be employed on the project for each type of concrete required.

4. Submit written reports to Architect/Engineer of proposed mix for each type of concrete at least 30 days prior to start of precast unit production. Do not begin concrete production until mixes and evaluations have been reviewed and approved by Architect and Engineer and Owner's testing laboratory.

5. Mix design adjustments may be requested when characteristics of materials, job conditions, weather, test results, or other circumstances warrant. Laboratory test data for revised mix designs and strength results must be submitted to and accepted by Architect and Engineer and Owner's testing laboratory before using in the work.

6. Limit use of fly ash to 25 percent replacement of portland cement by weight and slag cement to 50 percent of portland cement by weight; metakaolin and silica fume to 10 percent of portland cement by weight.

7. Produce normal weight concrete consisting of specified portland cement, aggregates, admixtures and water to produce the following properties:

    a. Compressive Strength at 28 days: 5,000 psi minimum at 28 days, or as required by design or as noted on the drawings.
    b. Release Strength: The minimum release strength for prestressed units shall be 3500 psi.
    c. Drying Shrinkage Limit: 0.03% at 28 days.

8. Produce lightweight concrete consisting of specified portland cement, aggregates, admixtures and water to produce the following properties:

    a. Compressive Strength: 5,000 psi minimum at 28 days, or as required by design or as noted on the drawings.
    b. Split-Cylinder Tensile Strength: The split cylinder strength factor as determined by ASTM C496 ($F_{ct}/(f'_c)^{0.5}$) shall not be less than 5.7.
    c. Air-dry density: Not less than 110 nor more than 116 pounds per cubic foot.
    d. Release Strength: The minimum release strength of prestressed members shall be 3500 psi unless noted otherwise and permitted by design.
    e. Drying Shrinkage Limit: 0.03% at 28 days.

C. Admixtures:

1. Comply with ACI 212.2R.

2. Use air-entraining admixture in concrete unless otherwise indicated.

3. Use water-reducing admixtures in strict compliance with manufacturer's directions. Admixtures to increase cement dispersion, or provide increased workability for low-slump concrete, may be used subject to Architect and Engineer's approval.

4. Use amounts as recommended by admixture manufacturer for climatic conditions prevailing at time of placing. Adjust quantities of admixtures as required to maintain quality control.

D. Embedded Items: Accurately position and secure cast-in anchorage devices. Locate anchorages where they do not affect position of reinforcement or placing of concrete. Do not relocate bearing plates or reinforcing steel in units unless approved in writing by the Architect and Engineer. Provide and coordinate the placement of embeds required for equipment or components hung from precast units.

E. Reinforcement Installation:

1. Clean reinforcement of loose rust and mill scale, earth and other materials which reduce or destroy bond with concrete.

2. Accurately position, support and secure reinforcement against displacement by formwork, construction, or concrete placement operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers and hangers, as specified by CRSI Manual of Standard Practice.

3. Place reinforcement to obtain at least the minimum coverages for concrete protection as specified in the drawings. Arrange, space and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.

F. Tensioning: Pretensioning of tendons for prestressed concrete may be accomplished either by single strand tensioning method or multiple-strand tensioning method. Comply with PCI MNL-116 requirements.

G. Concrete Placement: Place concrete in a continuous operation to prevent formation of seams or planes of weakness in precast units, complying with requirements of ACI 301. Thoroughly consolidate placed concrete by internal and/or external vibration without dislocation or damage to reinforcement and embedded items.

H. Identification:

1. Provide permanent markings to identify pick-up points and orientation in the structure, complying with markings indicated on final shop drawings. Imprint date of casting on each precast unit on a surface which will not show in finished structure.

2. Provide additional marking as required by local building codes or ordinances.

I. Curing:

1. Cover all precast and precast/prestressed concrete members with tarpaulins or other suitable means immediately after casting.

2. Curing by low-pressure steam, by steam vapor, by radiant heat and moisture, or other similar process may be employed to accelerate concrete hardening and to reduce curing time.

J. Detensioning:

1. Delay detensioning of prestressed units until concrete has attained design release strength, as established by test cylinders.

2. If concrete has been heat-cured, perform detensioning while concrete is still warm and moist to avoid dimensional changes which may cause cracking or undesirable stresses in concrete.

3. Detensioning of prestressed tendons may be accomplished either by gradual release of tensioning jacks or by heat cutting tendons, using a sequence and pattern to prevent shock or unbalanced loading.

K. Finishes:

1. Commerical Structural Finishes

   a. Commercial Grade: Remove large fins and protrusions and fill large holes. Rub or grind ragged edges. Faces are to be true, well-defined surfaces. Air holes, water marks, and color variations are acceptable. Allowable form joint offsets are limited to 3/16 in.
   b. Standard Grade: Normal plant-run finish produced in forms that impart a smooth finish to concrete. Surface holes smaller than 1/2 inch caused by air bubbles, normal color variations, form joint marks, and minor chips and spalls are acceptable. Fill air holes greater than 1/4 inch in width that occur in high concentration (more than one per 2 $in.^2$) . Major or unsightly imperfections, honeycombs, or structural defects are not permitted. Allowable joint offset is limited to 1/8 inch.
   c. Grade B Finish: Fill air pockets and holes larger than 1/4 inch in diameter with sand-cement paste matching color of adjacent surfaces. Fill air holes greater than 1/8 inch in width that occur in high concentration (more than one per 2 $in.^2$). Grind smooth form offsets or fins larger than 1/8 inch. Repair surface blemishes due to holes or dents in forms. Discoloration is permitted at form joints.
   d. Grade A Finish: Repair and/or fill all surface blemishes with the exception of air holes 1/16 inch in width or smaller and form marks where the surface deviation is less than 1/16 inch. Float-apply a neat cement-paste coating to exposed surfaces. Rub dried paste coat with burlap to remove loose particles. Discoloration is permitted at form joints. Grind smooth all form joints.

2. Commercial Architectural Finishes: Exposed faces shall be free of joint marks, grain, or other obvious defects. Corners, including false joints shall be uniform, straight and sharp. Finish exposed-face surfaces of structural precast concrete units to match approved mockups and as follows:

   a. Smooth-Surface Finish: Provide surfaces free of excessive air voids, sand streaks, and honeycombs, with uniform color and texture.
   b. Textured-Surface Finish: Impart by form liners to provide surfaces free of excessive air voids, streaks, and honeycombs, with uniform color and texture.
   c. Bushhammer Finish: Use power or hand tools to remove matrix and fracture coarse aggregates.
   d. Retarded Finish: Use chemical retarding agents applied to forms and washing and brushing procedures to expose aggregate and surrounding matrix surfaces after form removal.

e. Abrasive-Blast Finish: Use abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces.
f. Acid-Etched Finish: Use acid and hot-water solution, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces. Protect hardware, connections and insulation from acid attack.
g. Honed Finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures.
h. Polished Finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures.
i. Sand-Embedment Finish: Use selected stones placed in a sand bed in bottom of form, with sand removed after curing.

3. Unformed Surface: Provide light broom finish to unformed surfaces unless otherwise indicated. Consolidate concrete, bring to proper level with a straightedge, and apply the finish as specified.

4. Finish of Treads of Stair Units: For units cast top side up, provide a steel troweled finish followed by a light broom finish parallel to the length of the unit. For units cast top side down, provide a light sandblast on the tread area to produce a non-skid surface before delivery to the job site.

5. Finish of Top Surface of Composite Members: Top surfaces of double tees, hollow-core plank or other precast members scheduled to receive a topping shall have a rough scratch finish with surface transversely scarified to provide ridges approximately 1/4" deep.

6. Finish of Exposed Ends of Units: Strands shall be recessed ¾" minimum and recess shall be filled with non-shrink, non-metallic grout. Sandblast ends to provide a proper surface for sealant adhesion.

7. Holes: Cast in holes for openings in flanges larger than 10" in diameter or 10" square in accordance with final approved shop drawings. Other smaller holes will be field cut by trades requiring them, as acceptable to Engineer. Do not cut through stems of double tees, or through any prestressed members without Architect and Engineer approval.

L. Joint Widths: Unless shown otherwise on the drawings, provide joint widths in accordance with MNL-135.

3.2 QUALITY ASSURANCE

A. General: The Precast producer shall comply with noted standards and perform tests and inspections as described below to assure the specified quality in the final product.

B. Production Tolerances:

1. Provide production tolerances in accordance with PCI MNL-135.

2. Precast units having dimensions not conforming to specified tolerances will be rejected if appearance or function of the structure is adversely affected. Repair, or remove and replace rejected units as required to comply with contract documents. The Architect and Engineer must approve all repairs.

C. Concrete Strength Verification: Mold and test concrete cylinders as follows:

1. Cylinders for strength tests shall be molded and cured in accordance with ASTM C31 and tested in accordance with ASTM C39.

2. Minimum of two (2) per bed for each pour to verify specified release strength.

3. Minimum of two (2) per 50 cubic yards for each class of concrete to verify 28-day strength but not less than one set per day's operation.

4. Lightweight Concrete: An additional two cylinders per 50 cubic yards for each class of concrete used to perform splitting-cylinder tensile tests at 28 days.

5. Test cylinders shall be cured with and by the same methods as the members they represent.

D. Acceptance Criteria of Concrete Strength: The compressive strength level of an individual class of concrete shall be considered satisfactory if both the following requirements are met:

1. The average of all sets of three consecutive strength tests equal or exceed the required f'c.

2. No individual strength test falls below the required f'c by more than 500 psi.

3. If criteria 1 above is not met but criteria 2 above has been, the Precast Producer shall immediately notify the Engineer by telephone or email and take immediate steps to increase the average of subsequent strength tests.

4. If criteria 2 is not met, the Engineer shall be immediately notified by telephone or email and all units cast from the concrete that is represented by the low strength test shall be considered potentially deficient and subject to further tests or replacement.

E. Acceptance of Units: Precast units will be considered potentially deficient requiring the unit to be either further tested or replaced if the manufacturing processes fail to comply with any of the requirements which may affect the strength of the precast units, including but not limited to the following conditions:

1. Failure to meet compressive strength tests requirements

2. Failure to meet split cylinder strength requirements for lightweight concrete.

3. Reinforcement, reinforcement placing, and pretensioning and detensioning of tendons of prestressed concrete not conforming to specified fabrication requirements.

4. Visual evidence of cracks exceeding .02 inches wide, excessive negative camber, or deflection in excess of calculated anticipated amounts.

5. Concrete curing and protection of precast units not as specified.

6. Precast units damaged during storage, transportation, handling or erection.

F. Investigation of Low Concrete Strength: When there is evidence that the strength of precast concrete units does not meet specification requirements, the Precast Manufacturer's testing service shall take cores from hardened concrete for compressive strength determination, complying with ASTM C 42 and as follows:

1. Take at least 3 representative cores from precast units of suspect strength from locations directed by the Architect and Engineer.

2. Test cores in a saturated-surface-dry condition in accordance with ACI 318 if concrete will be wet during use of completed structure.

3. Test cores in an air-dry condition in accordance with ACI 318 if concrete will be dry during use of completed structure.

4. Strength of concrete for each series of cores will be considered satisfactory if their average compressive strength is at least 85% of 28-day design compressive strength and no individual test is less than 75% of the required f'c.

5. Test results will be reported in writing on same day that tests are made, with copies to Owner, Architect, Engineer, and General Contractor. Include in test reports the project identification name and number, date, name of precast concrete manufacturer name of concrete testing service, identification letter, number and type of member or members represented by core tests, design compressive strength, compression breaking strength and type of break (corrected for length-diameter ratio), direction of applied load to core with respect to the horizontal plane of concrete as placed, and moisture condition of core at time of testing.

6. Where core test results are satisfactory and precast units are acceptable for use in work, fill core holes solid with non-shrink patching mortar or epoxy based mortar as directed by Architect and Engineer and finish to match adjacent concrete surfaces.

G. X-Rays: The Architect or Engineer may order x-rays taken of any member if there is sufficient doubt about the proper existence or location of reinforcing steel, embedded items, or strands.

H. Load Tests: The Architect or Engineer may order a load test of the member in the plant or in the field if there is sufficient evidence to question the structural integrity of the member.

I. Repair of Out-of-Tolerance Finishes: Defects exceeding the criteria established in the specified finish, provided the structural capacity is not impaired, shall be cause for repair by patching with a two-part epoxy mortar or rejection of the unit. Patching shall be done only when acceptable to Architect and Engineer. The patch shall match the color, texture and finish of the original unit. All concrete surface repairs except those for minor surface blemishes that are less than the specified minimum must be noted in quality control reports and submitted for Architect and Engineer review and approval for each occurrence prior to erection. Patches not conforming to these requirements may be a cause for rejection of the unit.

J. Products Not Meeting Specifications: Precast units that do not conform to all specified requirements including strength, tolerances, both fabrication and erection, and finishes shall be rejected and replaced with units meeting all requirements of the Contract Documents, unless approval by the Architect and Engineer is obtained in writing for an authorized repair.

K. Authorized Repairs: No structural or architectural repair shall be made to any precast unit either in the plant or in the field without written documented approval for each occurrence in the form of a letter or drawing from the Architect or Engineer. Unauthorized repair details shall not be allowed.

3.3 INSTALLATION

A. General:

1. Examine supporting structure and conditions under which precast concrete work is to be erected and provide written notification of conditions detrimental to proper and timely completion of work. Do not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to Erector.

2. General Contractor shall monitor all phases of erection to ensure the work is in conformance with the contract documents.

3. Erect members by means of suitable lifting devices at points provided by the manufacturer.

4. Provide temporary shoring and bracing as required to ensure stability during erection. The erector shall brace unsymmetrical sections during erection and pouring of topping slabs to prevent rotation and instability regardless of whether it is specified on the erection drawings. The responsibility for bracing such members shall rest solely with the Erector.

5. Properly align, plumb and level precast units. Level out variations between adjacent members by shimming, loading or any other feasible method recommended by the manufacturer and acceptable to the Architect and Engineer.

6. Provide accurate placement and alignment of anchor bolts, plates or dowels in supporting structural elements.

7. Provide true, level bearing surfaces on all field placed foundations, bearing walls and other supporting members.

8. Bearing Pads: Install specified bearing pads as precast units are being erected and maintain in correct position until precast units are placed.

B. Erection Tolerances: Erection tolerances shall conform to PCI MNL-135

C. Field Welding:

1. Perform welding in compliance with AWS D1.1 and D1.4.

2. Protect units from damage by field welding operations and provide non-combustible shields as required.

3. Remove all lifting loops and touch-up paint all galvanized field welded connections as specified.

4. Repair damaged metal surfaces by cleaning and applying a coat of zinc-rich coating to galvanized surfaces and primer compatible with painted surfaces.

D. Exposed surfaces of all plates embedded in concrete shall be painted with zinc-rich coating specified above after the field connection is complete.

E. Grouting Joints: After precast units have been set and secured, grout at specified locations shown on the drawings and as follows:

1. Provide non-shrink non-metallic grout under base plates, bearing plates, at all load-bearing joints, at all pockets and at all blockouts.

2. Provide forms or other acceptable method to retain grout in place until sufficiently hard to support itself. Pack spaces with stiff grout material, tamping until voids are completely filled. Place grout to finish smooth, plumb, and level with adjacent concrete surfaces. Keep grouted joints damp for not less than 48 hours after initial set. Promptly remove excess grout material and spillage from exposed surfaces before it hardens.

F. Powder-Actuated Fasteners and Expansion Anchors: Do not use powder-actuated fasteners or expansion anchors in precast prestressed units except as submitted and approved on shop drawings or other submittal.

G. Damage to Units During Installation: Damage to precast units sustained during installation resulting in spalls deeper than 1/4 inch and cracks exceeding .01 inch in width shall be immediately reported to the Architect and Engineer. Units thus damaged shall be subject to repair or replacement as directed by the Architect and Engineer. Repairs of spalls shall be done using a two-part epoxy mortar patch that shall match the color, texture, and finish of the original unit. Cracks shall be repaired using an epoxy injection process.

3.4 ACCEPTANCE

A. Field Inspection: Acceptance of erected precast concrete will be made by the Architect and Engineer for general conformance with the plans and specifications.

B. Defective Work: Precast concrete units which do not conform to specified requirements, including strength, tolerances, and finishes, shall be repaired or replaced with precast concrete units that meet requirements of this section as directed by the Architect and Engineer. The Contractor shall also be responsible for the cost to any other work affected by or resulting from corrections to precast concrete work.

3.5 QUALITY ASSURANCE TESTING AND INSPECTION DURING CONSTRUCTION

A. See Testing Laboratory Services section of these Specifications for concrete materials and concrete inspection and test requirements.

END OF SECTION 03 41 00

SECTION 03 45 00 – PRECAST ARCHITECTURAL CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 01 - Specification sections, apply to work of this section.

1.2 SCOPE OF WORK

A. Provided all labor, material, and equipment to cast, fabricate, deliver, and erect all architectural precast concrete as shown on the Architectural Drawings and in schedules.

B. Architectural Precast Concrete shall include the following unit types:

1. Plain smooth faced concrete units.

2. Exposed aggregate units (integral, not surface applied aggregate).

3. Special formed and textured units.

C. Precast prestressed structural concrete units are specified under another section of Division 03.

D. Caulking, sealants, and gaskets are specified in Division 07.

1.3 QUALITY ASSURANCE

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

A. Codes and Standards: Comply with provisions of following codes, specifications and standards, except as otherwise indicated:

1. ACI 318 "Building Code Requirements for Reinforced Concrete.

2. Concrete Reinforcing Steel Institute, "Manual of Standard Practice".

3. Prestressed Concrete Institute MNL 117, "Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products".

4. PCI Manual for Structural Design of Architectural Precast Concrete as published by the Prestressed Concrete Institute.

5. PCI Design Handbook, Fourth Edition, as published by the Prestressed Concrete Institute.

B. Fabricator Qualifications: Firms which have a minimum of 2 years successful experience in the fabrication of architectural precast concrete units, similar to units required for this project, will be acceptable. Fabricator must have sufficient production capacity to produce, transport, and deliver required units without causing delay in the work.

C. Fabrication Qualifications: Produce precast concrete units at fabrication plant engaged primarily in manufacturing of similar units, unless plant fabrication or delivery to site is impractical.

If units are not produced at precast concrete fabricating plant, maintain procedures and conditions for quality control equivalent to plant production.

D. Design Responsibility:

1. Design: The design and detailing of all Architectural Precast Concrete and their connections shall be the responsibility of the precast fabricator. This shall include all bolts, plates, braces, weld sizes, and any embedded items in both precast and the structural frame for all connections between the precast and the support frame. The design shall be performed by or under the direct supervision of a registered professional engineer in the state where the project is located. Design calculations, stamped by the registered engineer, shall be submitted for Engineer review.

Design modifications may be made only as necessary to meet field conditions and to ensure proper fitting of the work, and only as acceptable to the Architect. Maintain general design concept shown without increasing or decreasing sizes of members or altering profiles and alignment shown. Provide complete design calculations and drawing prepared and stamped by a registered professional engineer in the state where the project is located.

2. Design Procedure: Design calculations shall consider and show stress from dead load of panel, wind load, and erection loads. Wind loads shall be as specified in the project General Notes of the structural drawings or as shown on the architectural drawings.

E. Erector Qualifications: Regularly engaged for at least 2 years in the erection of architectural precast structural concrete similar to the requirements of this project. Upon request, provide written evidence that equipment and personnel are adequate and qualified for performance of contract requirements.

F. Welder and Welding Machine Operator Qualifications: All field and plant welders shall be certified in accordance with AWS D1.1 for the type of welding required.

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver precast concrete units to project site in such quantities and at such times to assure continuity of installation. Any storage of units at the project site shall be done so as to prevent cracking, distortion, warping, staining, or other physical damage and so that markings are visible. Lift and support units only at designated lifting or supporting points as shown on final shop drawings.

1.5 SUBMITTALS

A. Certification and Test Reports: Submit manufacturer's specifications and instructions for manufactured materials and products. Include manufacturer's and plant's certifications and laboratory test reports for the following:

1. PCI Plant Certification.

2. Concrete mix designs, including sources of coarse, fine and lightweight aggregates as well as admixtures and fly ash.

3. Prestressing strand mill certificates.

4. Mill certificates for reinforcing bars and welded wire mesh.

5. Mill certificates for high strength reinforcing bars.

6. Structural steel mill certificates.

7. Welder and welding operator certifications.

8. Calibrations of prestressing jacks.

9. Calibration of cylinder testing machine.

10. Mill certificates for cement.

11. Cylinder test reports on concrete for all precast units.

12. Compressive strength test reports for structural grout.

13. Certification from the bearing pad manufacturer verifying conformance with standards set forth in Division 2, Section 25 of AASHTO Standard Specification for Highway Bridges.

14. Certification from manufacturer of slide bearing assemblies verifying conformance with ASTM D1457.

15. Manufacturer's identification number as an approved fabricator in accordance with the City of Houston Policy Memorandum Relative to Fabricators, Prefabricated Construction and Certifying Agencies, Revision 1 issued November 4, 1982.

B. Product Data: Submit manufacturer's specifications, data and instructions for manufactured materials and products. Include manufacturer's certifications and laboratory test reports as required.

C. Shop Drawings: Submit shop drawings showing complete information for fabrication and installation of precast concrete units.

1. Indicate member dimensions and cross-section, location, size and type of reinforcement, including special reinforcement and lifting devices necessary for handling and erection.

2. Indicate erection procedure for precast units, sequence of erection, and required handling equipment.

3. Show layout, dimensions, and identification of each precast unit corresponding to sequence and procedure of installation.

4. Indicate welded connections by AWS standard symbols. Detail inserts, connections, and joints including accessories and construction at openings in precast unit.

5. Show location and details of anchorage devices that are to be embedded in other construction.

6. Coordination with Structural Steel Detailer: Prior to the start of the structural steel shop drawings, the precaster shall furnish the Architect/Engineer a set of shop drawings showing the location of all gravity and lateral connections to the structure. The General Contractor shall furnish this information to the structural steel detailer, after it has been approved by the Architect/Engineer, and prior to the completion of structural steel shop drawings.

D. Design Calculations: The Precaster's design of all precast elements shall be submitted for Engineer approval. Such calculations shall be performed by or under the direct supervision of a registered professional engineer in the state where the project is located. The calculations shall be bound with the Engineer's signature, seal, and date stamped on the cover sheet. Calculations shall be indexed by precast element and arranged in a logical orderly fashion. Incomplete submittals will be rejected. Where computer aided design is submitted, the input data shall be included and output must be clear. At least one hand calculation shall be submitted for each member type designed by computer.

E. Samples: Submit samples (minimum 3) approximately 12" X 12" and of appropriate thickness, to illustrate quality, color, and texture of surface finish prior to commencement of production. One will be returned to the General Contractor and one to the precaster prior to production. All approved samples shall be initialed by the Architect.

1. Submit samples of cast-in gaskets, anchorages, and other attachments and accessories as requested by Architect.

2. Prepare a full-size sample of each required architectural precast concrete unit for the Architect's inspection at production plant or on site prior to start of installation work, and after Architects review of finish samples. Acceptable full-size samples may be incorporated in job installation.

PART 2 - PRODUCTS

2.1 FORMWORK

A. Provide forms and, where required, form facing materials of metal, plastic, wood, or other acceptable material that is non-reactive with concrete and will produce required finished surfaces. Rust-stained or excessively worn forms that would impair the quality of the finished surface are not acceptable. Comply with recommendations set forth in ACI Standard 347, Recommended Practice for Concrete Formwork.

B. Accurately construct forms mortar-tight and of sufficient strength to withstand pressures due to concrete placing operations, temperature changes, and when prestressed, the pretensioning and detensioning operations. Maintain formwork to provide completed precast concrete units of shapes, lines, and dimensions indicated on the approved shop drawings within specified fabrication tolerances.

C. Unless forms for plant-manufactured prestressed concrete units are stripped prior to detensioning, design forms so that stresses are not induced from precast units due to deformation of concrete under prestress or to movement during detensioning.

2.2 REINFORCING MATERIALS

A. Reinforcing Bars: ASTM A615, Grade 60, except all reinforcing steel required to be welded shall conform to ASTM A 706.

B. Galvanized Reinforcing Bars: ASTM A767, Class II.

C. Epoxy Coated Reinforcing Bars: ASTM A775.

D. Steel Wire: ASTM A82, plain, cold-drawn steel.

E. Welded Wire Fabric: ASTM A185.

F. Deformed Steel Wire: ASTM 496.

G. Welded Deformed Steel Wire Fabric: ASTM A497.

H. Prestressing Tendons: Uncoated, 7-wire, stress-relieved strand; ASTM A416, Grade 270K.

I. Prestressing Bars: ASTM A722.

J. Supports for Reinforcement:

1. Provide supports for reinforcement including bolsters, chairs, spacers and other devices for spacing, supporting or fastening reinforcing, complying with CRSI recommendations.

2. For exposed-to-view concrete surfaces where legs of supports are in contact with forms, provide supports with legs which are plastic protected (CRSI Class 1) or stainless steel protected (CRSI Class 2).

2.3 CONCRETE MATERIALS

A. Portland Cement: ASTM C 150, Type I or Type III.

Use only one brand and type of cement throughout the project, unless otherwise acceptable to Architect.

1. Use "buff" color portland cement for facing concrete mix to match Architect's control sample.

2. Use "White" portland cement for facing concrete mix to match Architect's control sample.

3. Standard "gray" portland cement may be used for non-exposed back-up concrete.

B. Coarse Aggregate: ASTM C 33; hard, durable, carefully selected and graded; free of material causing staining or reacting with cement.

Use aggregates from same sources as those used in Architect's control sample.

C. Fine Aggregate: ASTM C 33; manufactured sand of same material as coarse aggregate, unless otherwise acceptable to Architect.

D. Water: Drinkable, free from foreign materials in amounts harmful to concrete and embedded steel.

E. Air-Entraining Admixture: ASTM C 260.

F. Admixtures:

1. Air-Entraining; complying with ASTM C260 and as manufactured by:

   a. Dayton Superior Corp.
   b. Gifford-Hill & Co., Inc.
   c. W. R. Grace & Co.
   d. Master Builders

2. Water-Reducing; complying with ASTM C494, Type A and as manufactured by:

   a. Gifford-Hill & Co.
   b. W. R. Grace & Co.
   c. Monier Resources

3. Fly Ash; complying with ASTM C618 and as manufactured by:

   a. Monier Resources
   b. Ash Management System

4. Calcium Chloride; Not permitted

2.4 CONNECTION MATERIALS

A. Steel Plates: ASTM A36.

B. Steel Shapes: ASTM A36.

C. Anchor Bolts: Non-headed type with tensile strength requirements conforming to ASTM A36, unless otherwise indicated. Provide regular hexagon nuts and carbon steel washers

D. High Strength Anchor Bolts: Non-headed type made from threaded round stock conforming to ASTM A572 Grade 50 or A572 Grade 42 as shown on the drawings or high-strength bars conforming to ASTM A722. Where grade is not specifically shown, ASTM A572 Grade 50 anchor bolts shall be furnished.

E. Weldable Reinforcing Bars: ASTM A706.

F. Headed Studs: ASTM A108, 60,000 psi minimum tensile strength.

G. Deformed Bar Anchors: ASTM A496, 70,000 psi minimum yield strength.

H. Prestressing Steel Bars: ASTM A722.

Approved Manufacturer: Dywidag Systems International, USA, Inc.

I. Threaded Rods: ASTM A36.

J. Welding Electrodes: Comply with AWS D1.1.

K. Ductile Iron Inserts: ASTM A536.

Approved Manufacturers:

1. Richmond Screw Anchor Company, Inc.

2. Hohman & Barnard, Inc.

3. Dayton Superior Corporation.

L. Corrosion Protection of Materials: Shop prime all items that are cast in the supporting concretes and concrete units. All other connection material shall be hot dip galvanized in accordance with ASTM A 153. Touch-up after field welding with zinc-rich coating as manufactured by Sherwin-Williams (Zinc-Clad 5 B69 A 45) or ZRC Cold Galvanizing Compound. Exposed surfaces of all plates embedded in concrete shall be painted with zinc-rich coating specified above after the field connection is complete.

2.5 BEARING PADS

A. Elastomeric Pads:

1. Provide structural grade chloroprene bearing pads with Shore A durometer hardness of 60 ± 5 and having a minimum thickness of 3/8" for tees, 1/2" for beams, and 1/4" for slabs, unless otherwise shown on the drawings. Bearing pads provided shall conform to Standard Specifications for Highway Bridges inclusive of all Interim Specifications up to date adopted by the American Association of State Highway and Transportation Officials.

2. Design bearing pads in accordance with recommendations set forth in PCI Design Handbook, Fourth Edition.

3. Size pads so that both surfaces are in complete contact with the bearing pads. The design bearing pressure shall not exceed 800 psi under total service load, and 500 psi under dead load. Pads greater than 1 1/4" in thickness shall be laminated with steel plates (min. 1/16" thick) molded into the material.

4. Provide beveled, plain elastomeric bearing pads between non-parallel load surfaces.

5. Approved manufacturers of elastomeric pads:

a. Oil States Industries, Inc.
b. Scougal Rubber Co., Inc.
c. Con-Serv, Inc.
d. JVI Inc.
e. Tulsa Rubber Co.
f. Old North Manufacturing Co.

B. Tetrafluoroethylene (TFE) Slide Bearings:

1. Glass-filled virgin Teflon slide bearings as shown on the drawings and as manufactured by:

a. EGC Corporation
b. Con-Serv, Inc.
c. Fluorocarbon

2.6 GROUT MATERIALS

A. Nonshrink Grout: All base plates, bearing plates, and concrete bearing joints shall be grouted with non-shrink non-metallic grout as specified herein. Provide premeasured, prepackaged, non-metallic, non-corrosive, non-staining material requiring only the addition of water complying with the following:

1. Corps of Engineers Specification for Nonshrink Grout (CRD-C621).

2. Attain 28 day compressive strength as determined by grout cube tests conforming to ASTM C109 in accordance to the following:

a. 6,000 psi for supporting concrete up to 3,000 psi.
b. 8,000 psi for supporting concrete between 3,000 psi and 4,000 psi.
c. 10,000 psi for supporting concrete greater than 4,000 psi.

3. Follow manufacturer's directions and recommendations for mixing and placing grout.

4. Grout to be similar in color to that of surrounding concrete.

5. Acceptable non-shrink grouts:

a. "Supreme" as manufactured by Gifford Hill Co.
b. "Crystex" as manufactured by L&M Construction Chemicals, Inc.
c. "Five Star Grout" as manufactured by U.S. Grout Corp.

B. Sand Cement Grout: Provide sand cement grout for grouting all pockets and blockouts in precast members and in grouting prestressed ducts where specified on the drawings. Sand cement grout shall consist of Portland Cement (ASTM C 150 Type I or III), sand (ASTM C33), and water. Proportions by weight shall be one part cement, 2 1/4 to 2 1/2 parts sand, and the minimum amount of water required to obtain a workable mix. Minimum compressive strength shall be 3500 PSI at 28 days. Admixtures to accelerate the set or prevent freezing may be utilized, except the use of admixtures containing chlorides will not be permitted.

PART 3 - EXECUTION

3.1 FABRICATION

A. General: Fabricate precast concrete units complying with manufacturing and testing procedures, quality control recommendations and dimensional tolerances of PCI MNL-116 and MNL-117, and as specified for types of units required.

B. Proportioning and Design of Mixes:

1. Prepare design mixes for each type of concrete required.

2. Design mixes may be prepared by an independent testing facility or by qualified precast manufacturing personnel, at precast manufacturer's option.

3. Proportion mixes by either trial batch or field experience methods, using materials to be employed on the project for each type of concrete required, complying with ACI 211.1 or ACI 211.2.

4. Submit written reports to Architect/Engineer of proposed mix for each type of concrete at least 30 days prior to start of precast unit production. Do not begin concrete production until mixes and evaluations have been reviewed and approved by Architect/Engineer and Owner's testing laboratory.

5. Mix design adjustments may be requested when characteristics of materials, job conditions, weather, test results, or other circumstances warrant. Laboratory test data for revised mix designs and strength results must be submitted to and accepted by Architect/Engineer and Owner's testing laboratory before using in the work.

6. Produce normal weight concrete consisting of specified portland cement, aggregates, admixtures and water to produce the following properties:

   a. Compressive Strength at 28 days: 5,000 psi minimum at 28 days, or as required by design or as noted on the drawings.
   b. Release Strength: The minimum release strength for prestressed units shall be 3500 psi.

7. Produce lightweight concrete consisting of specified portland cement, aggregates, admixtures and water to produce the following properties:

   a. Compressive Strength: 5,000 psi minimum at 28 days, or as required by design or as noted on the drawings.
   b. The split cylinder strength factor ($F_{ct}/(f'_c)^{0.5}$) shall not be less than 5.7 and a drying shrinkage limit of 0.03% at 28 days.
   c. Air-dry density: Not less than 110 nor more than 116 pounds per cubic foot.
   d. Release Strength: The minimum release strength of prestressed members shall be 3500 psi.

8. Cure compression test cylinders using the same methods as will be used for the precast concrete work.

C. Admixtures:

1. Comply with ACI 212.2R.

2. Use air-entraining admixture in concrete unless otherwise indicated.

3. Use water-reducing admixtures in strict compliance with manufacturer's directions. Admixtures to increase cement dispersion, or provide increased

workability for low-slump concrete, may be used subject to Architect/Engineer's approval.

4. Use amounts as recommended by admixture manufacturer for climatic conditions prevailing at time of placing. Adjust quantities of admixtures as required to maintain quality control.

D. Embedded Items: Accurately position and secure cast-in anchorage devices. Locate anchorages where they do not affect position of reinforcement or placing of concrete. Do not relocate bearing plates or reinforcing steel in units unless approved in writing by the Architect/Engineer.

E. Reinforcement Installation:

1. Clean reinforcement of loose rust and mill scale, earth and other materials which reduce or destroy bond with concrete.

2. Accurately position, support and secure reinforcement against displacement by formwork, construction, or concrete placement operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers and hangers, as specified by CRSI Manual of Standard Practice.

3. Place reinforcement to obtain at least the minimum coverages for concrete protection as specified in the drawings. Arrange, space and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.

F. Tensioning: Pretensioning of tendons for prestressed concrete may be accomplished either by single strand tensioning method or multiple-strand tensioning method. Comply with PCI MNL-116 requirements.

G. Concrete Placement: Place concrete in a continuous operation to prevent formation of seams or planes of weakness in precast units, complying with requirements of ACI 304 and ACI 309. Thoroughly consolidate placed concrete by internal and/or external vibration without dislocation or damage to reinforcement and embedded items.

H. Identification:

1. Provide permanent markings to identify pick-up points and orientation in the structure, complying with markings indicated on final shop drawings. Imprint date of casting on each precast unit on a surface which will not show in finished structure.

2. Provide additional marking as required by local building codes or ordinances.

I. Curing:

1. Cover all precast and precast/prestressed concrete members with tarpaulins or other suitable means immediately after casting.

2. Curing by low-pressure steam, by steam vapor, by radiant heat and moisture, or other similar process may be employed to accelerate concrete hardening and to reduce curing time.

3. Test cylinders shall be cured with and by the same methods as the members they represent.

4. Make test cylinders as follows:

   a. Minimum of two (2) per bed for each pour to verify specified release strength.
   b. Minimum of two (2) per 50 cubic yards for each class of concrete to verify 28-day strength but not less than one set per days operation.
   c. Minimum of two (2) to verify release strength and two (2) for 28-day strength for small units or individual pieces.

J. Detensioning:

1. Delay detensioning of prestressed units until concrete has attained design release strength, as established by test cylinders.

2. If concrete has been heat-cured, perform detensioning while concrete is still warm and moist to avoid dimensional changes which may cause cracking or undesirable stresses in concrete.

3. Detensioning of prestressed tendons may be accomplished either by gradual release of tensioning jacks or by heat cutting tendons, using a sequence and pattern to prevent shock or unbalanced loading.

K. Finishes:

1. Architectural Surface Finishes:

   a. Abrasive blast finish, using abrasive grit, equipment, application techniques and cleaning to expose aggregate and surrounding matrix surfaces, to match Architect's control sample.
   b. Exposed aggregate finish, using chemical retarding agents applied to concrete forms, with washing and brushing procedures after form removal to match Architect's control sample.
   c. Bushhammer finish, using power and hand tools and cleaning procedures to match Architect's control sample.
   d. Smooth surface finish free of pockets, sand streaks, and honeycomb, with uniform color and texture to match Architect's control sample.
   e. Textured surface finish imparted by form liners or inserts to provide surfaces free of pockets, streaks and honeycomb, with uniform color and texture to match Architect's control sample.
   f. As-cast or float finish for unexposed surfaces.

2. Other Formed Surfaces: Provide normal plant run finish in forms that impart a smooth finish to concrete. Small surface holes caused by air bubbles, normal form joint marks, and minor chips and spalls may be acceptable, but no major or unsightly imperfections, honeycomb, or structural defects will be permitted.

3. Other Unformed Surfaces: Provide trowel finish to unformed surfaces unless otherwise indicated. Consolidate concrete, bring to proper level with a straightedge, and float and trowel to a smooth uniform finish.

3.2 FABRICATION TOLERANCES

Provide fabrication tolerances as follows:

A. Standard tolerances according to PCI MNL-116 and 117 and Part 8 of the PCI Design Handbook, Fourth Edition unless stricter requirements are specified on the drawings.

B. Areas or members with special tolerances are indicated on the plans.

C. Precast units having dimensions not conforming to specified tolerances will be rejected if appearance or function of the structure is adversely affected. Repair, or remove and replace rejected units as required to comply with contract documents. All repairs must be approved by the Architect/Engineer.

3.3 INSTALLATION

A. General:

1. Examine supporting structure and conditions under which precast concrete work is to be erected and provide written notification of conditions detrimental to proper and timely completion of work. Do not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to Erector.

2. General Contractor shall monitor all phases of erection to ensure the work is in conformance with the contract documents.

3. Erect members by means of suitable lifting devices at points provided by the manufacturer.

4. Deliver anchorage items which are to be embedded in other construction before start of such work. Provide setting diagrams, templates, instructions and directions as required for installation.

5. Properly align, plumb and level precast units. Level out variations between adjacent members by shimming, loading or any other feasible method recommended by the manufacturer and acceptable to the Architect/Engineer.

6. Provide accurate placement and alignment of anchor bolts, plates or dowels in supporting structural elements.

7. Provide true, level bearing surfaces on all field placed foundations, bearing walls and other supporting members.

8. Bearing Pads: Install specified bearing pads as precast units are being erected and maintain in correct position until precast units are placed. Bearing pads must be placed under all precast floor members unless specifically detailed otherwise on the drawings.

9. Do not install precast units until concrete has attained its 28 day design strength.

B. Erection Tolerances: Install precast concrete members plumb, level, and in alignment within PCI MNL-17 and PCI Design Handbook, Part 8, Fourth Edition specified limits of erection tolerances. Provide temporary supports and bracing as required to maintain position, stability and alignment as members are being permanently connected.

Maintain horizontal and vertical joint alignment and uniform joint width as erection progresses. Deflections of the supporting frame may occur as panels are erected, necessitating readjustment, alignment, and possibly resetting of certain panels to meet specified tolerances. It is the responsibility of the precast erector to consider such deflection, whether specifically indicated on the drawings or not, and provide for same in the erection process at no additional cost to the Owner.

Anchor units in final position by bolting, welding, grouting, or as otherwise indicated. Remove temporary shims, wedges, and spacers as soon as possible after anchoring is completed.

1. At bolted connections use lock washers or other acceptable means to prevent loosening of nuts.

2. At welded connections apply rust inhibitive coating on damaged areas, same as shop applied material. Use galvanizing repair coating on galvanized surfaces.

C. Field Welding:

1. Perform welding in compliance with AWS D1.1 and D1.4.

2. Protect units from damage by field welding operations and provide non-combustible shields as required.

3. Remove all lifting loops and touch-up paint all galvanized field welded connections as specified.

4. Repair damaged metal surfaces by cleaning and applying a coat of liquid galvanizing repair compound to galvanized surfaces and primer compatible with painted surfaces.

D. Accessories: Install clips, hangers, and other accessories required for erection of precast units to supporting members and back-up materials.

E. Cleaning: Clean exposed facings to remove dirt and stains which may be on units after erection and completion of joint treatments. Wash and rinse in accordance with precast manufacturer's recommendations. Protect other work from damage due to cleaning operations. Do not use cleaning materials or processes which could change the character of exposed concrete finishes.

3.4 DAMAGED OR MISCAST UNITS

A. Any units that are noticeably cracked from the process of lifting, handling, or any other reason shall be replaced by the Contractor at no additional cost to the Owner.

B. Concrete units which are not formed as shown on the drawings or are out-of-tolerance or show a defective finish shall be considered as not conforming with the intent of this specification and shall be removed from the job and replaced by the Contractor at no additional cost to the Owner.

3.5 CONCRETE SURFACE REPAIRS

A. Classification:

1. Structural Repair: Major defective areas including cracks, spalls, or honeycombs that affect the structural integrity of the unit shall require a structural repair using a two part epoxy bonder and/or epoxy mortar. Location of structural repairs shall be at the discretion of the Architect/Engineer.

2. Cosmetic Repair: Minor defective areas in units that do not affect the structural integrity of the unit shall require a cosmetic repair using a non-shrink patching mortar and bonding agent. Location of cosmetic repairs shall be at the discretion of the Architect and Engineer.

B. Method: The method of repair shall be approved by the Architect/Engineer after samples are submitted for review by the Contractor.

C. Waiver: Permission to patch or repair any area shall not be considered as a waiver of the Architect's right to require complete removal of the defective work if the repair does not, in the opinion of the Architect, satisfactorily restore the quality and appearance of the work.

3.6 PERFORMANCE REQUIREMENTS

A. Conduct inspections, perform testing, and make repairs or replace unsatisfactory precast units as required.

Limitations as to the amount of patching which will be permitted is subject to acceptance of Architect.

B. In addition to above, in-place precast units may be rejected for any one of the following:

1. Exceeding the specified installation tolerances.

2. Damaged during construction operations.

3. Exposed-to-view surfaces which develop surface finish deficiencies.

4. Other defects as listed in PCI MNL-117.

C. Products Not Meeting Specifications: Precast units that do not conform to all specified requirements including strength, tolerances, both fabrication and erection, and finishes shall be rejected and replaced with units meeting all requirements of the Contract Documents, unless approval by the Engineer, Architect and Owner is obtained in writing for an authorized repair.

D. Authorized Repairs: No structural or architectural repair shall be made to any precast unit either in the plant or in the field without written documented approval for each occurrence in the form of a letter or drawing from the Engineer, Architect, and Owner. Unauthorized repair details shall not be allowed.

END OF SECTION 03 45 00

SECTION 03 54 16 - HYDRAULIC CEMENT UNDERLAYMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

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

1.3 ALLOWANCES

A. Furnish hydraulic-cement-based underlayment as part of underlayment allowance.

B. Furnish and install hydraulic-cement-based underlayment as part of underlayment allowance.

1.4 UNIT PRICES

A. Work of this Section is affected by underlayment unit price.

1.5 ACTION SUBMITTALS

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

B. LEED Submittals (Projects authorized for LEED certification only):

1. Product Data for Credit IEQ 4.2: For priming and sealing coatings, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For priming and sealing coatings, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Include plans indicating substrates, locations, and average depths of underlayment based on survey of substrate conditions.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Product Certificates: Signed by manufacturers of underlayment and floor-covering systems certifying that products are compatible.

C. Minutes of preinstallation conference.

1.7 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.

C. Fire-Resistance Ratings: Where indicated, provide hydraulic-cement underlayment systems identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.

D. Sound Transmission Characteristics: Where indicated, provide hydraulic-cement underlayment systems identical to those of assemblies tested for STC and IIC ratings per ASTM E 90 and ASTM E 492 by a qualified testing agency.

E. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store materials to comply with manufacturer's written instructions to prevent deterioration from moisture or other detrimental effects.

1.9 PROJECT CONDITIONS

A. Environmental Limitations: Comply with manufacturer's written instructions for substrate temperature, ventilation, ambient temperature and humidity, and other conditions affecting underlayment performance.

1. Place hydraulic-cement-based underlayments only when ambient temperature and temperature of substrates are between 50 and 80 deg F.

1.10 COORDINATION

A. Coordinate application of underlayment with requirements of floor-covering products and adhesives, to ensure compatibility of products.

PART 2 - PRODUCTS

2.1 HYDRAULIC-CEMENT-BASED UNDERLAYMENTS

A. Underlayment: Hydraulic-cement-based, polymer-modified, self-leveling product that can be applied in minimum uniform thickness of 1/4 inch and that can be feathered at edges to match adjacent floor elevations.

1. Basis of Design Product: Subject to compliance with requirements, provide K-15 Self-Levelling Underlayment Concrete by Ardex, Aliquippa, PA, or a comparable product by one of the following :

    a. Bonsal American, an Oldcastle company; ProSpec Level Set 200 . www.bonsal.com
    b. Dayton Superior Corporation; LeveLayer. www.daytonsuperior.com
    c. Substitutions: See Section 01 25 00 - Product Requirements.

2. Cement Binder: ASTM C 150, portland cement, or hydraulic or blended hydraulic cement as defined by ASTM C 219.
3. Compressive Strength: Not less than 4000 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.

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.

D. Reinforcement: For underlayment applied to wood substrates, provide galvanized metal lath or other corrosion-resistant reinforcement recommended in writing by underlayment manufacturer.

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

1. Primer shall have a VOC content of 200 g/L or less when calculated according to 40 CFR 59, Subpart D.
2. Primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. Corrosion-Resistant Coating: Recommended in writing by underlayment manufacturer for metal substrates.

1. Coating shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D.
2. Coating shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for conditions affecting performance.

1. Proceed with application only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. General: Prepare and clean substrate according to manufacturer's written instructions.

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

B. Concrete Substrates: Mechanically remove, according to manufacturer's written instructions, 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.**] <**Insert value**> 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.

1. Install underlayment reinforcement recommended in writing by manufacturer.

D. Metal Substrates: Mechanically remove, according to manufacturer's written instructions, rust, foreign matter, and other contaminants that might impair underlayment bond. Apply corrosion-resistant coating compatible with underlayment if recommended in writing by underlayment manufacturer.

E. Nonporous Substrates: For ceramic tile, quarry tile, and terrazzo substrates, remove waxes, sealants, and other contaminants that might impair underlayment bond, and prepare surfaces according to manufacturer's written instructions.

F. Adhesion Tests: After substrate preparation, test substrate for adhesion with underlayment according to manufacturer's written instructions.

G. Sound Control [**Mat**] [**and**] [**Board**]: Install sound control materials according to manufacturer's written instructions.

1. Do not install mechanical fasteners that penetrate through the sound control materials.

3.3 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.

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 according to manufacturer's written instructions. 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.

3.4 PROTECTION

A. Protect underlayment from concentrated and rolling loads for remainder of construction period.

END OF SECTION 03 54 16