

SECTION 03 30 00

CAST-IN-PLACE-CONCRETE

PART 1 – GENERAL

1.01 SUMMARY

- A. Provide cast-in-place concrete for general building construction where indicated on drawings and specifications:
 - 1. Footings, foundations, piers and retaining walls (where indicated).
 - 2. Building slabs on grade and ground supported post-tension foundation system concrete (where indicated).
 - 3. Requirements (materials, mixes, finishes) apply to concrete work specified in other sections; refer to individual sections for reference.

1.02 SUBMITTALS

- A. Comply with Section 01 33 00.
- B. Product Data: Upon request submit manufacturer's data and installation instructions for the following items when used:
 - 1. Concrete admixtures.
 - 2. Curing, sealers, hardeners and densifiers.
 - 3. Miscellaneous materials.
- C. Shop Drawings: Upon request submit concrete reinforcement fabrication, bending and placement. Comply with ACI 315 showing bar schedules, stirrup spacing, diagrams of bent bars, and arrangement of concrete reinforcement.
- D. Concrete Mix Design: Submit 1 copy of concrete mix design for each strength or composition of concrete to be used.

1.03 QUALITY ASSURANCE

- A. Comply with governing codes and regulations. Provide products of acceptable manufacturers, which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.
- B. Standards: Comply with the provisions of the following specifications and standards, except as otherwise noted or specified, or as accepted or directed by the Architect.
 - 1. ACI 301, Specifications for Structural Concrete for Buildings.
 - 2. ACI 305.1 and ACI 306.1-90, Specifications for Hot and Cold Weather Concreting.
 - 3. ACI 318, Building Code Requirements for Reinforced Concrete.
 - 4. Concrete Reinforcing Steel Institute, Manual of Standard Practice.
 - 5. Environmental Protection Agency (EPA) volatile organic compound (VOC) evaporation requirements.

1.04 FIELD SAMPLING AND TESTING

- A. Comply with Section 01 45 16.
- B. Testing Laboratory and Reporting: Owner shall employ a qualified independent testing laboratory to perform material evaluations of sampling and testing specified. Submit test results within 7 days of obtaining data. Laboratory Strength Test reports shall contain the following information:
 - 1. Batch plant identification.
 - 2. Project identification.
 - 3. Date of testing.

4. Sample identification and location within construction.
 5. Design mix used including materials, water / cement ratio, admixtures, and recorded slump.
 6. Compressive strength results, developed at 7 days and 28 days.
- C. Samples:
1. Field samples shall be made and cured in accordance with ASTM C31-12, for each concrete strength, at the rate of 3 test cylinders and one slump test for each 40 cubic yards or fraction thereof, from each day's pour and record locations for report.
 2. Test cylinders (6in. X 12 in.) shall be as follows: One (1) at 7 days, two (2) at 28 days, and reserve the remaining for testing after a longer period as required by the Owner if the 28 day test does not meet the required strength. If test cylinders (4 in. X 8 in.) are cast then One (1) at 7 days, three (3) at 28 days, with no reserve for testing after a longer period. Either coring may be performed or an additional three (3) cylinders may be requested by the Owner for the resolution of 28 day test cylinders that do not meet the required strength In accordance with ASTM C173-12 Volumetric Method, or ASTM C231-10 Pressure Method, make air content check for each set of test cylinders.
 3. The taking of samples from small pours of 10 cubic yards or less may be omitted at the discretion of the Owner.
 4. Additionally, test slump every 25 cu. yd. recording location for report.
 5. When early form removal is requested, field cure cylinders tested at 7 or less days to determine sufficient strength.
- D. Testing:
1. Where strength of any group of 3 cylinders or of any individual cylinder fall below minimum compressive strength specified, the Owner shall have the right to require that test specimens be cut from the structure. Specimens shall be selected by Owner from location in structure represented by test specimen or specimens which failed.
 2. Specimens shall be secured, prepared, and tested in accordance with ASTM C42-10, within a period of 60 days after placing concrete.
 3. Concrete shall be considered to meet the strength requirements of this specification if it meets the strength requirements of ACI 318.
 4. Should laboratory analysis indicate that the proper concrete mix has not been used by the Contractor, all such concrete poured using the improper mix shall be subject to rejection.
 5. The cost of cutting specimens from the structure, patching the resulting holes, and making the laboratory analysis shall be borne by the Contractor.
 6. The holes from which the cored samples are taken shall be packed solid with no slump concrete proportioned in accordance with the ACI 211 "Recommended Practice for Selecting Proportions of No-Slump Concrete". The patching shall have the same design strength as the specified concrete.
 7. If any of the specimens cut from the structure fail to meet the requirements outlined in ACI 318. The Owner shall have the right to require any and all defective concrete to be replaced and all cost resulting therefrom shall be borne by the Contractor.
 8. Additional Sampling: In addition to the slump tests specified above, the Contractor shall keep a cone (mold) and rod apparatus on the job site for random testing of batches. When concrete does not meet the specified slump requirements, and when directed by the Owner, immediately perform a slump test in accordance with ASTM C143-12. Concrete not meeting the slump requirements shall be removed from the job site.

PART 2 – PRODUCTS

2.01 FORM MATERIALS

- A. Form Materials:
 - 1. For Exposed Finish Concrete: Plywood, metal or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces.
 - 2. For Unexposed Finish Concrete: Use plywood, lumber, metal, or other acceptable material. If lumber is used, it must be dressed on at least 2 edges and 2 sides for a tight fit.
- B. Form Coatings: Commercial formulated form coating compound that will not bond with, stain, nor adversely affect concrete surfaces, will not impair subsequent treatments or finishes requiring bond or adhesion, nor impede wetting of concrete surfaces by water or curing compound. Comply with Environmental Protection Agency (EPA) volatile organic compound (VOC) evaporation requirements.

2.02 REINFORCEMENT MATERIALS

- A. Steel Reinforcement:
 - 1. Refer to drawings for reinforcement sizes and spacing.
 - 2. Reinforcing Bars: ASTM A 615(S1), Grade 60, deformed billet steel bars of grades as indicated on the drawings, free from loose rust, scale and other coatings that may reduce bond.
 - 3. Mesh or Fabric Reinforcement: ASTM A185-07, welded wire fabric.
 - 4. Tie Wires: Soft annealed iron wire not smaller than 18 gage.
 - 5. Fiber Reinforcement: **(NOT PERMITTED)**.
- B. Accessories: Include all spacers, chairs, ties, and other devices necessary for properly spacing and fastening reinforcement in place. Use plastic protected reinforcing bar supports conforming to CRSI Class 1 specification for exposed finish concrete.

2.03 CONCRETE MATERIALS

- A. Concrete Materials:
 - 1. Portland Cement: ASTM C150-12, Type I.
 - 2. Normal Weight Concrete Aggregates: ASTM C33-13, and the following:
 - a. Fine Aggregate: Clean, sharp, natural or manufacturer sand, free from loam, clay, lumps, or other deleterious substances.
 - b. Coarse Aggregate: Clean, uncoated, processed, locally available, non-reactive aggregate, containing no clay, mud, loam, or foreign matter; maximum size 1-1/2".
 - c. Combined aggregate gradation for slabs and other designated concrete shall be 8% - 18% for large top size aggregates (1½ in.) or 8% - 22% for smaller top size aggregates (1 in. or ¾ in.) retained on each sieve below the top size and above the No. 100.
 - 3. Mixing Water: Clean, free from oil, acid, salt, injurious amounts of vegetable matter, alkalies, and other impurities; potable.
- B. Admixtures:
 - 1. Water-Reducing Admixture: ASTM C494-13, Type A.
 - a. Euclid: Eucon or Plastol Series.
 - b. BASF: Pozzolute , PolyHeed, or Glenium Series.
 - c. W.R. Grace: WRDA, Daracem, Mira, Zyla, or Adva Series.
 - d. Sika Chemical: Plastiment, Plastocrete, ViscoCrete, Sikaplast, or Sikament Series.
 - 2. Water-Reducing and Retarding Admixture: ASTM C494-13, Type B or D.
 - a. Euclid: Eucon Retarder 75.
 - b. BASF: Pozzolith or Delvo Series,
 - c. W.R. Grace: Recover or Daratard 17
 - d. Sika Chemical: Plastiment or Plastocrete Series.

3. Water-Reducing and Accelerating Admixture: ASTM C 494-13, Type C or E. (Non-Corrosive, Non-Chloride only permitted)
 - a. Euclid: Accelguard Series.
 - b. BASF: Pozzolith or Pozzutec Series.
 - c. W.R. Grace: Daraset, Daracel, Lubricon, Polarset, or DCI Series.
 - d. Sika Chemical: Plastocrete 161 FL, Plastocrete 161 HE, Sikaset NC, Sika Rapid 1, or Sikaset HE.
4. High-Range Water-Reducing and Retarding Admixture (Super Plasticizer): ASTM C494-13, Type F or G.
 - a. Euclid: Eucon Series.
 - b. BASF: MasterGlenium Series.
 - c. W.R. Grace: ADVA Series.
 - d. Sika Chemical: Sikament or ViscoCrete Series.
5. Air Entrained Admixture: ASTM C260-10a.
 - a. Euclid: Aea Series.
 - b. BASF: MB-VR or MB-AE Series.
 - c. W.R. Grace: Dorex AEA.
 - d. Sika Chemical: Sika Aer.
6. Alkali-Silica Reactivity Inhibitor: ASTM C1293-08b, formulated lithium nitrate admixture for the prevention of alkali-silica reactivity (ASR) in concrete.
 - a. Euclid: Eucon Integral ARC.
 - b. BASF: ASRx 30 LN.
 - c. W.R. Grace: RASir.
7. Fly Ash Admixture: Use of quality fly ash by weight will be permitted as a cement reducing admixture by 15% maximum. Provide fly ash meeting requirements of ASTM C618-12a, Class C or Class F with the following special requirements. Loss on ignition in Table I shall not exceed 3%. Compliance to Table IA shall apply. Amount retained on the 325 sieve in Table 2 shall not exceed 20%. Chemical analysis of the fly ash shall be reported in accordance with ASTM C114-11b. Submit report indicating for a 6 month period immediately prior to submittal date, weekly test and tests results performed on concrete with fly ash admixture.
8. Prohibited Admixtures: Calcium chloride, thiocyanates or admixtures containing more than 0.05% chloride ions. Upon request provide admixture manufacturer's written certification that chloride ion content complies with specified requirements.
9. Other Admixtures: Do not use other admixtures unless accepted in writing by Architect.

2.04 PROPORTIONING OF MIXES, BATCHING AND MIXING

- A. Concrete Mix Design:
 1. Prepare design mixes for each type of concrete, in accordance with ACI 301 and ACI 318, except as otherwise specified.
 2. Proportion design mixes by weight for class of concrete required, complying with ACI 211, except as otherwise specified.
 3. Proposed mix designs shall be accompanied by complete standard deviation analysis or trial mixture test data. Submit written reports to the Owner for design mix at least 15 calendar days prior to the start of work. If trial batches are used, gross weight and yield per cu. yd. of trial mixtures. Proposed mix design shall list the following information.
 - a. Batch plant identification and location.
 - b. Concrete materials and water cement ratios.
 - c. Strength. Compressive strength developed at 7 days and 28 days.
 - d. Measured slump.
 - e. Air content range.
 - f. Admixtures used.

- B. Strength: Concrete minimum ultimate strength shall be 4,000 psi at 28 days in accordance with ASTM C94-13, unless otherwise noted on drawings.
- C. Water/Cement Ratio:
 - 1. Concrete subject to freezing and thawing shall have a maximum water/cementitious material ratio of 0.48 by weight (4,000 psi at 28 days).
 - 2. All concrete subjected to deicers and/or required to be watertight shall have a maximum water/cementitious material ratio of 0.48 (4000 psi at 28 days or more).
 - 3. No water shall be added to ready-mixed concrete at the job site.
- D. Air-Entrainment: Use air-entrained admixture in strict compliance with manufacturer's directions.
 - 1. All concrete exposed to freezing and thawing and/or required to be watertight shall have an air content of 4.5% to 7.5%.
 - 2. All interior slabs shall have an air content of 3% maximum.
- E. Admixture Usage: Use admixtures in strict compliance with manufacturer's directions.
 - 1. Concrete for interior floor slabs must contain specified high range water-reducing admixture (superplasticizer).
 - 2. All Concrete less than 8 inches thick, and slabs placed at air temperatures below 50° F shall contain specified non-corrosive non-chloride accelerator.
 - 3. Concrete required to be air entrained shall contain an approved air-entraining admixture.
 - 4. Pumped concrete, architectural concrete, concrete required to be watertight, and concrete with water/cement ratio below 0.50 shall contain specified high-range water-reducing admixture (superplasticizer).
- F. Slump Limits:
 - 1. Concrete containing no high-range water-reducing admixture shall have slump of 4" plus or minus 1".
 - 2. Concrete containing high-range water-reducing admixture (superplasticizer) shall have a maximum slump of 8" unless otherwise approved by Architect. Concrete shall arrive at job site at slump of 2" to 3", be verified, then high-range water-reducing admixture added to increase slump to approved level.
- G. Batching and Mixing: Concrete may be ready-mixed or job-mixed at the Contractor's option, in accordance with governing building code and with the referenced ACI 318. No hand mixing allowed.

2.05 CURING, SEALERS, HARDNERS AND DENSIFIERS

- A. General:
 - 1. Provide products compatible with finish flooring materials, special finish systems or polished concrete finish systems specified. Refer to drawing finish schedule for types and locations.
 - 2. Comply with Environmental Protection Agency (EPA) volatile organic compound (VOC) evaporation requirements.
- B. Curing Materials: (Used on freshly placed interior concrete surfaces to receive tile, resilient flooring, or additional surface treatments and finishing which ALLOW proper dissipation of curing material.)
 - 1. Dissipating resin curing compound, ASTM C309-11, Type I, with fugitive dye. Film must chemically break down within 30 day period when exposed to UV conditions.
 - 2. Coverage Rate: Per manufacturer's recommendations, but not less than 300 sq. ft. per gallon.
 - 3. Manufacturers: Euclid "Kurex DR 100", L&M "Cure R", ChemMasters "Spray-Cure Clear", Sierra TK Products "TK-2519 DC WB", or approved equal.
- C. Curing and Sealing Materials: (Used on exterior exposed concrete surfaces of slabs, curbs, sidewalks, and interior concrete surfaces NOT subject to additional surface treatments and finishing.)

1. High solids curing and sealing compound, ASTM C1315-11, transparent, acrylic, solvent-based, 30% minimum solids content, moisture loss of not more than 0.40 kg/sq. meter. when applied at coverage rate of 300 sq. ft. per gallon.
 2. Coverage Rate: Per manufacturer's recommendations, but not less than 300 sq. ft. per gallon minimum.
 3. Manufacturers: Euclid "Super Aqua-Cure VOX", BASF "Kure-N-Seal 30", L&M "Dress & Seal WB30", or approved equal.
- D. Additional Surface Treatments and Finishing Materials:
1. Sealer, Hardener and Densifier Materials: (To be used on interior concrete to receive polished concrete finishing). Comply with Section 03 35 43.
 2. Liquid Densifier Treatment Materials: (Used on interior concrete as an exposed finish.)
 - a. Penetrating concrete densifier, odorless, colorless, non-yellowing sodium silicate solution designed to harden, dustproof and protect concrete floors.
 - b. Coverage Rate: Per manufacturer's recommendations, but not less than 200 sf. ft. per gallon minimum.
 - c. Manufacturers: Curecrete Distribution "Ashford Formula", Euclid "Eucosil", L&M "Sealhard", Prosoco "Consolideck Blended Densifier", or approved equal.

2.06 MISCELLANEOUS MATERIALS

- A. Connectors: Provide all metal connectors required for placement in cast-in-place concrete, for the attachment of structural and non-structural members.
- B. Expansion Joint Filler: ASTM D1751-04, non-extruding premoulded material, ½" thick, unless otherwise noted, composed of fiberboard impregnated with asphalt, except use ASTM D1752-04a, Type II, resin-bound cork for walks and other exposed areas. Sonneborn "Sonoflex F" closed cell polyurethane foam expansion joint filler is acceptable.
- C. Vapor Barrier: Conform with ASTM E1745-11, Class A, tensile strength 45 lbf/in, puncture resistance 2200 grams, polyethylene film, .010" thick minimum. Visqueen or approved equal.
- D. Non-Shrink Grout: CRD-C 621, factory pre-mixed grout.
 1. Metallic: Master Builders "Embeco 885", Euclid "Hi-Mod Grout", or L&M "Ferrogrout".
 2. Non-Metallic: Master Builders "Construction Grout", Euclid "Eucon-NS", or L&M "Crystex".
- E. Bonding Agent: Polyvinyl acetate, rewettable type; W.R. Grace "Daraweld C", Larsen "Weldcrete", Euclid "Eucoweld", or L&M "Everbond".
- F. Patching Mortar: Free-flowing, polymer-modified cementitious coating; BASF "MBT Underlayment – Self leveling", Euclid "ThinCoat", Sika Chemical "Sikatop 120", or Thoro "Thoro Underlayment".

PART 3 – EXECUTION

3.01 TOLERANCES:

- A. ACI Standards shall govern concrete work except where specified differently.
- B. Floor flatness and levelness tolerances: Subfloors Under Materials Such As Vinyl, Tile, Paint and Carpet: ACI 302.1R and ASTM E1155-96, floor flatness (Ff) of 40, floor levelness (Fl) of 40.
- C. Variation from plumb:
 1. 0 to 10 feet: ¼" maximum.
 2. 20 feet or more: 3/8" maximum.
- D. Variation in thickness:
 1. Footings: 5%
 2. Slabs: +3/8" and -1/4"

- E. Variation in grade:
 1. 0 to 10 feet: ¼" standard, 1/8" for floor slabs.
 2. 10 to 20 feet: 3/8" standard, ¼" for floor slabs.
 3. 40 feet or more: ¾" standard, 3/8" for floor slabs.
- F. Variation in plan:
 1. 0 to 20 feet: ½".
 2. 40 feet or more: ¾" standard, plus ½" for footings.
- G. Variation in eccentricity: 2% for footings.
- H. Variation in openings:
 1. Size: plus 1/8".
 2. Location: ¼".
- I. Variation in stairs & landings:
 1. Consecutive steps:
 - a. Treads: 1/8".
 - b. Risers: 1/16".
 2. Flight of Stairs:
 - a. Treads: ¼".
 - b. Risers: 1/8".

3.02 FORM WORK

- A. Design, erect, support, brace and maintain formwork to support vertical and lateral loads that might be applied until such loads can be supported by the concrete structure. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation and position.
- B. Construct forms complying with ACI 347, to sizes and 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, molding, rustications, reglets, chambers, blocking, screeds, bulkheads, anchorages and inserts, and other features required in work. 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 the concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces.
- D. 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 on forms at inconspicuous location.
- E. Chamfer exposed corners and edges ¾" unless otherwise indicated. Where applicable use wood, metal, PVC or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.
- F. Form Ties: Factory-fabricated, adjustable-length, removable or snap-off metal form ties, designed to prevent form deflection, and to prevent spalling concrete surfaces upon removal.
- G. Preparation of Form Surfaces: Coat the contact surfaces of forms with a form-coating compound where applicable before reinforcement is placed.
- H. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses, and chases from trades providing such ties. Accurately place and securely support items built in to form.
- I. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris just before concrete is placed. Retighten forms after concrete placement, if required, to eliminate mortar leaks.

3.03 PLACING REINFORCEMENT

- A. Comply with the Concrete Reinforcing Steel Institute (CRSI) "Recommended Practice for Placing Reinforcing Bars", and as indicated on drawings and herein specified.
- B. Clean reinforcement of loose rust, mill scale, dirt, and other materials or coatings, which reduce or destroy bond with concrete.
- C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcing by chairs, spacers, and hangers as required. Set wire ties so ends are pointed into concrete.
- D. In all cases, provide minimum concrete protection over bar reinforcement of at least 3" unless otherwise indicated on drawings.
- E. Do not place bars more than 2" beyond the last leg of continuous support. Do not use supports to hold runways for conveying equipment.
- F. Install mesh welded wire fabric reinforcement in as long lengths as practicable, lapping pieces at least one mesh plus 2" but in no case less than 8". Lace splices with wire. Offset end laps to prevent continuous laps in either direction. All welded wire fabric reinforcement must be securely supported at three feet maximum in each direction.

3.04 JOINTS AND INSERTS

- A. Joints: Provide slab joints, sawed joints and formed construction joints. Locate and install joints, which are not shown on drawings, so as not to impair the strength and appearance of the structure. Submit joint layout to Architect if requested.
- B. Inserts: Set and build into the work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete. Properly locate all embedded items in cooperation with other trades, and secure in position before concrete is placed. Use setting drawings, diagrams, instructions, and directions provided by suppliers of the items to be attached thereto.

3.05 CONCRETE PLACEMENT

- A. Comply with ACI 304, and as herein specified.
- B. Pre-Placement Inspection: Before placing concrete, clean and inspect formwork, reinforcing steel, and items to be embedded or cast-in. Notify other crafts in ample time to permit the installation of their work, and cooperate with them in setting such work, as required. Make sure soil treatment for termite control has been applied, where required, before vapor barrier, subbase, and concrete are installed. Coordinate the installation of joint materials and vapor barriers with placement of forms and reinforcing steel.
- C. Vapor Barrier: Apply directly over compacted subgrade and under subbase. Lay with 6" wide side laps and end laps and seal watertight with manufacturer's adhesive. Lay film just before subbase is placed and protect against punctures. Repair punctures with adhesive-applied extra sheet before proceeding.
- D. Notify the Testing Company 24 hours before placing any concrete. Coordinate governmental inspections, if required, with agency having jurisdiction. Allow sufficient time for inspection of reinforcing and for corrective action prior to scheduled concrete placement.
- E. Concrete Mix Admixtures (On Site Mixing): Where used or required as indicated, add to concrete mix at rates or quantity per admixture manufacturer's recommendations for project conditions prior to conveying. Admixture type and mixing procedures shall be documented on site by Owner's independent testing laboratory.
- F. Conveying: Convey concrete from the mixer to the place of final deposit by methods that will prevent the separation or loss of materials. Provide equipment for chuting, pumping, and pneumatically conveying concrete of proper size and design as to insure a practically continuous flow of concrete at the point of delivery and without segregation of the materials. Keep open troughs and chutes clean and free from coatings of hardened concrete. Do not allow concrete to drop freely more than 10 feet.

Do not use vibrators to transport concrete inside of forms. All equipment and methods used for conveying are subject to the approval of the Architect.

- G. Depositing: Deposit concrete continuously or in layers of such thickness that no concrete will be placed on hardened concrete so as to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as specified. Deposit concrete near or in its final location to avoid segregation due to rehandling or flowing, and displacement of the reinforcement.
- H. Cold Weather Placing: Comply with the requirements of ACI 306.
- I. Hot Weather Placing: Comply with the requirements of ACI 305.
- J. Compaction: Consolidate concrete during placing operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners. When using vibrators, insert and withdraw vibrators vertically at uniformly spaced locations not farther than the visible effectiveness of the machine. Place vibrators to rapidly penetrate the placed layer of concrete and at least 6" into the proceeding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion, limit the duration to the time necessary to consolidate the concrete and complete embedment or reinforcement and other embedded items without causing segregation of the mix.

3.06 FINISH OF FORMED SURFACES

- A. Rough Form Finish: For formed concrete surfaces not exposed to view in the finished work or by other construction, unless otherwise indicated. This is the concrete surface having texture imparted by form facing material used, with tie holes and defective areas repaired and patched, fins and other projections exceeding ¼" in height rubbed down or chipped off.
- B. Smooth Form Finish: For formed concrete surfaces exposed to view, or that are to be covered with a coating material applied directly to concrete, or a covering material applied directly to concrete, such as waterproofing, damp-proofing, painting or other similar system. This is as-cast concrete surface obtained with selected form facing material, arranged orderly and symmetrically with a minimum of seams. Repair and patch defective areas with fins or other projections completely removed and smooth.
- C. Smooth Rubbed Finish: Provide a smooth rubbed finish for exposed concrete surfaces and surfaces which have received smooth form finish treatment not later than one day after form removal. Moisten concrete surfaces and rub smooth with carborundum brick or other abrasive until uniform color and texture is produced. Do not apply cement grout other than that created by rubbing process.

3.07 SLAB FINISHES

- A. Place, consolidate, strike off and level concrete slab to proper elevation. After the concrete has stiffened sufficiently to permit the operation, and water sheen has disappeared, float surface at least twice to uniform sandy texture.
- B. Trowel Finish: After floating, trowel surface at least twice to smooth dense finish.
- C. Slabs to Receive Floor Covering: Finish as in paragraph "Trowel Finish" above, except trowel to remove trowel marks and to smooth, even finish; omit second troweling.
- D. Slabs to Receive Polished Concrete Finishing:
 - 1. Comply with additional requirements of Section 03 35 43.
 - 2. Provide hard steel trowel finish with a minimum of 3 passes with power trowel to achieve Class 5 finish as described in ACI 302.1R to comply with minimum tolerances of Ff and FI specified herein.
- E. Non-Slip Broom Finish: (At exterior walks, steps, and elsewhere as indicated).

3.08 REMOVAL OF FORMS

- A. Do not remove forms until the concrete has attained 67% or 28 day strength or minimum of 4 days. Use a method of form removal that will not cause overstressing of the concrete.

3.09 CONCRETE CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing, and when curing procedure will not mar surface. Weather permitting; keep continuously moist for not less than 7 days. Begin final curing procedures immediately following initial curing and before concrete has dried. Continue final curing for at least 7 days in accordance with ACI 301 procedures. Avoid rapid drying at end of final curing period.
- B. Curing Methods: Perform curing of concrete by moist curing, by moisture-retaining cover curing, by curing compound, by curing and sealing compound, and by combinations thereof, as herein specified. **Curing method and project conditions shall be compatible with subsequent additional surface treatments and finishing products and procedures. Review drawings for finish types and locations to coordinate requirements with other trades.**
 - 1. Provide moisture curing by keeping concrete surface continuously wet by covering with water, by water-fog spray, or by 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 12" lap over adjacent absorptive covers. Do not allow Absorbent Cover materials to dry out during specified curing period.
 - 2. Provide moisture-cover curing by covering concrete surface with specified moisture-retaining cover, placed in widest practicable width with sides and ends lapped at least 12" and sealed with waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape. The cover shall be placed flat on the concrete surface, avoiding wrinkles, to minimize mottling immediately after wetting the slab to rejection. It shall be placed and weighted so that it remains in contact with the concrete during the specified duration of curing. Windrows of sand or earth, or pieces of lumber shall be placed along all edges and joints in the film to retain moisture and prevent wind from getting under the film and displacing it.
 - 3. Surfaces of exterior exposed concrete surfaces of slabs, curbs, sidewalks, and interior concrete surfaces NOT subject to additional surface treatments and finishing.): Provide curing and sealing compound meeting ASTM C1315-11 as follows:
 - a. Apply specified curing and sealing compound to concrete slabs as soon as final finishing operations are complete (within 2 hours). Apply uniformly in continuous operation by power-spray or roller in accordance with manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.
 - b. Do not use membrane curing and sealing compounds on surfaces which are to be covered with coating material applied directly to concrete, waterproofing, painting, and other coatings and finish materials, unless otherwise acceptable to Architect.
 - 4. Surfaces of freshly placed interior concrete slabs to receive tile, resilient flooring, or other subsequent additional surface treatments and finishing which ALLOW proper dissipation of curing material: Provide dissipating resin curing compound meeting ASTM C309-11 as follows:
 - a. Apply specified dissipating resin curing compound to concrete slabs as soon as final finishing operations are complete (within 2 hours). Apply uniformly in continuous operation by power-spray or roller in accordance with

- A. General: Repair and patch defective areas with cement mortar of the same type and class as the original concrete, immediately after removal of forms. Cut out honeycomb, rock pockets, voids over ½" diameter, and holes left by tie rods and bolts, down to solid concrete but in no case to a depth of less than 1". Make edges of cuts perpendicular to the concrete surface, before placing cement mortar in the same manner as adjacent concrete. Proprietary patching compounds may be used when acceptable to the Architect.
- B. Smooth, Exposed-To-View Surfaces: Blend cements so that, when dry, patching mortar will match color of surrounding concrete. Provide test areas at inconspicuous location to verify mixture and color match before proceeding with patching. Compact mortar in place and strike-off slightly higher than surrounding surface.
- C. Concealed Formed Surfaces: Repair defects that adversely affect the durability of the concrete. If defects cannot be repaired, remove and replace the concrete.
- D. Other repair methods may be used, subject to Architect's acceptance.

3.014 CLEAN-UP

- A. Do not allow debris to accumulate. Clean up all concrete and cement materials, equipment and debris upon completion of any portion of the concrete work, and upon completion of the entire cast-in-place concrete work.

END OF SECTION

SECTION 03 35 43

POLISHED CONCRETE FINISHING

PART 1 - GENERAL

1.01 SUMMARY

- A. Provide polished concrete finishing system where indicated on drawings, complete. This section includes the following:
 - 1. Concrete floor substrate grinding to specified finish.
 - 2. Applying sealer, hardener and densifier and performing grinding and polishing to specified finish.
 - 3. Application of protective sealer and stain inhibitor and polishing to specified finish.
- B. Special Note: Products, materials, tolerances and installation requirements specified under this section shall govern over requirements specified in other related sections. Coordinate with polished concrete finish locations indicated on drawings.

1.02 SUBMITTALS

- A. Comply with Section 01 33 00.
- B. Test Reports: Upon request provide sheen gloss reading test results conducted as specified and recorded on floor plan diagram confirming compliance with specified performance criteria.
- C. Warranty: Provide 10 year product manufacturer's warranty agreeing to replace and repair defective materials that may occur within the warranty period at no cost to the Owner.
- D. Installer's Certification: Provide letter documenting Installer's accreditation and certification compliance as specified under quality assurance.

1.03 QUALITY ASSURANCE

- A. The following specifications are provided as a guide to the minimum "Polishing/Grinding Steps" and liquid densifier/sealer applications required. It is the contractor/installers ultimate responsibility to provide a diamond polished/ground floor meeting the specified criteria. In all cases the specified Surface Preparation and Cleaning steps, the minimum number of specified Diamond Polishing/Grinding Steps, the specified applications of liquid densifier and concrete stain inhibitor/sealer shall be performed.
- B. Comply with governing codes and regulations. Provide products of acceptable manufacturers which have been in satisfactory use in similar service for three years.
- C. Installer's Certification:
 - 1. Contact manufacturers specified for listing of approved Certified Installers.
 - 2. Use experienced installers who have successfully performed a minimum of 5 projects of at least 6000 square feet each. Upon request provide listing of projects and contact references.
 - 3. Upon request provide letter of certification from manufacturer stating that Installer is certified applicator of polished concrete finishing system specified and is familiar with proper procedures and installation requirements required by the manufacturer.
- D. Deliver, handle, and store materials in accordance with manufacturer's instructions. Maintain records of product container numbers.
- E. Standards: Comply with the provisions of the following specifications and standards, except as otherwise noted or specified, or as accepted or directed by the Owner..
 - 1. Comply with related standards indicated in Section 03 30 00 Cast-In-Place Concrete.

2. ASTM E 1155, Standard Test Method for Determining Floor Flatness and Levelness Using the F number system.
 3. ASTM E 430, Standard Test Methods for Measurement of Gloss of High-Gloss Surfaces by Abridged Goniophotometry.
 4. ASTM G23-81, Standard Test Method for Ultraviolet Light and Water Spray Resistance.
- F. Finish and Appearance Quality Standards per Concrete Polishing Association of America (CPAA):
1. Class level of cut / aggregate exposure based on the following criteria:
 - a. Class A - Cream: Polishing only the portland paste at the surface of the substrate without exposing small, medium or large aggregate.
 - b. Class B – Salt/Pepper: Exposing the fine aggregate such as sand and small aggregate within the substrate. The depth of grind will depend greatly on placement and finishing procedures. Generally this level of grind can be achieved within 1/16 inch of the surface.
 - c. Class C – Medium Aggregate: Exposing more of the overall girth of the aggregate within the substrate. The depth of grind will depend greatly on the placement and finishing procedures. Generally this level of grind can be achieved within 1/8 inch of the surface.
 - d. Class D – Large Aggregate: Exposing the overall girth of the aggregate within the substrate. The depth of grind will depend greatly on the placement and finishing procedures. Generally this level of grind can be achieved within ¼ inch of the surface.
 2. Level of sheen per ASTM E 430 when the concrete surfaced is mechanically processed. Gloss readings are not to be obtained through the use of any microfilming products, sealers, coating, enhancers or the result of resin transfer from resin bond abrasives. Readings shall be taken not less than 10' on center in field areas and within 1' of floor area perimeters. In no case shall a reading be below 2% of specified minimum sheen.
 - a. Level 1 Sheen (Flat) appearance with no to very slight diffused reflection.
 - b. Level 2 Sheen (Satin) as determined by gloss reading of 45-60 before application of specified concrete stain inhibitor and sealer. Not less than 5 step process concluding with 800 grit resin bonded tooling.
 - c. Level 3 Sheen (Semi-Gloss) as determined by gloss reading of 60-70 before application of specified concrete stain inhibitor and sealer. Not less than 6 step process concluding with 1500 grit resin bonded tooling.
 - d. Level 4 Sheen (High Gloss) as determined by gloss reading of 70 or higher before application of specified concrete stain inhibitor and sealer. Not less than 7 step process concluding with 3000 grit resin bonded tooling.

PART 2 – PRODUCTS

2.01 PROJECT SYSTEM PERFORMANCE AND APPEARANCE CRITERIA

- A. Concrete Mix Color: Natural without dyes or pigment additives.
- B. Quality Class Level of Cut: Class C – Medium Aggregate.
- C. Quality Level of Sheen: Level 2, Satin, Polished with 800 grit minimum, Gloss reading 45-60 per ASTM E 430.
- D. Ultra Violet Light and Water Spray: ASTM G23-81 – No adverse effect to ultra violet and water spray.

2.02 MATERIALS AND MANUFACTURERS

A. GENERAL

1. Compatibility: Provide products which are recommended by manufacturers to be fully compatible with project substrate conditions and special concrete floor finish materials, means and methods.
 2. Provide special concrete floor finish products from a single manufacturer unless otherwise approved.
 3. All products used shall comply with Environmental Protection Agency (EPA) volatile organic compound (VOC) evaporation requirements.
- B. CAST-IN-PLACE CONCRETE MATERIALS
1. Materials: Comply with Section 03 30 00. Materials and products shall be compatible with special concrete floor finish system.
- C. SEALER, HARDENER AND DENSIFIER PRODUCTS
1. Manufacturers: Contact manufacturers for listing of Certified Installers of specified products.
 - a. Advanced Flooring Products, 888-942-3144.
 - b. Euclid Chemical Company, 800-321-7628.
 - c. L&M Construction Chemicals, 800-362-3331.
 - d. L. M. Scofield Company, 800-800-9900.
 - e. Prosoco Inc., 800-255-4255.
 2. Concrete Sealer, Hardener and Densifier: Advanced Flooring Products "RetroPlate 99", Euclid "Euco Diamond Hard", L&M "FGS Hardener Plus", L. M. Scofield Company "Formula One Lithium Densifier MP, Prosoco "Consolideck LS" or approved equal.
 3. Concrete Stain Inhibitor and Sealer: Advanced Flooring Products "RetroGuard Stain Inhibitor and Sealer", Euclid "Euco Diamond Hard", L&M "PermaGuard SPS", L. M. Scofield Company "Formula One Guard-W", Prosoco "Consolideck Concrete Protector", or approved equal.
- D. AUXILIARY MATERIALS
1. Water: Potable.
 2. Joint Sealants: Semi-rigid, 2-component, self-leveling, 100% solids, rapid curing, polyurea control and expansion joint filler with Shore A 80 or higher hardness. Comply with Section 07 92 00. Materials and products shall be compatible with special concrete floor finish system. Use color that matches adjacent surface finish.
 3. Grinding and Polishing: Provide other related materials as recommend by manufacturer, not specifically described, but required for complete and proper system installation.
 4. Cleaning and Preparation Agents: Products recommended by manufacturer for project conditions.
 5. Protection Materials: Products recommended by manufacturer for project conditions.

PART 3 – EXECUTION

3.01 PROJECT CONDITIONS

- A. Environmental Requirements:
1. Comply with manufacturer's written instruction for substrate temperature and moisture content, ambient temperature and humidity, ventilation and other conditions affecting installation and performance of special concrete floor finish.
 2. Coordinate scheduling with Owner to provide completion of installation of special concrete floor finish prior to 10 days minimum of installation of racking and equipment for an uninhibited continuous application of finish system.
- B. Examination:
1. Inspect substrate and report unsatisfactory conditions in writing. Verify that surfaces and site conditions are ready to receive work. Correct conditions

detrimental to timely and proper installation of work. Beginning work means acceptance of substrate conditions.

2. Concrete must be cured for sufficient period recommended by the special concrete floor finish manufacturer before application can begin.
3. Comply with special concrete floor finish manufacturer's recommendations and instructions. Clean, prime and prepare substrate surfaces for proper installation.

C. Tolerances:

1. Comply with Section 03 30 00.
2. Where new or existing substrates are not in compliance with specified tolerances provide repair, grinding, patching or other remedies recommended by polished concrete floor finish manufacturer for project conditions and approved by the Owner and/or Architect.

D. Protection:

1. Provide manufacturer's approved substrate protection materials, means and methods to maintain and ensure system performance and appearance criteria specified.
2. Avoid surface deposits of oil, chemicals, agents or other material that will adversely affect special concrete floor finish performance or appearance. No satisfactory chemical or cleaning procedure may be available to remove petroleum stains from the concrete surface. Prevention is therefore essential.
3. All hydraulic powered equipment must be diapered to avoid staining of the concrete.
4. No trade will park vehicles on the inside slab. If necessary to complete work, drop cloths will be placed under vehicles at all times.
5. No pipe cutting machine shall be used on the inside floor slab.
6. Do not place steel on interior slab to avoid rust staining.
7. All equipment must be equipped with non-marking tires.
8. Do not drag or drop equipment or material across the slab which will scratch, chip or damage surfaces.

3.02 INSTALLATION

A. General:

1. Install polished concrete floor finishing system per manufacturer's recommendations and instructions. Use equipment, means and methods for proper installation.
2. Where walls, columns or substrate penetrations are installed adjacent to or through polished concrete floor finish areas, extend grinding and polishing process to within 1" maximum distance from perimeter of surface interrupting condition by means necessary for uniform appearance with field surface area finish.

B. Concrete Substrate Installation:

1. New Construction:
 - a. Comply with Section 03 30 00 and the governing requirements of this section.
 - b. Provide hard steel trowel finish with a minimum of 3 separate passes with power trowel to achieve Class 5 finish as described in ACI 302R to comply with minimum tolerances specified in this section.
 - c. Provide concrete curing and sealing materials compatible with special concrete floor finish system recommended by manufacturer.
2. Existing Construction:
 - a. Remove existing applied floor finish(s) including, but not limited to, carpet, VCT, tile, grout, mastic, adhesives, paint, epoxy or other non-concrete floor material to concrete substrate conditions by appropriate means and methods necessary for proper installation of new special concrete floor finish per manufacturer's recommendations.
 - b. Where existing substrates are not in compliance with specified tolerances provide repair, grinding, patching or other remedies recommended by special

concrete floor finish manufacturer for project conditions and approved by the Owner and/or Architect

- C. Concrete Substrate Grinding and Polishing:
 - 1. Use equipment, means and methods recommended by manufacturer.
 - 2. Grind, polish and clean concrete floor surfaces using methods depending on substrate conditions to achieve project system performance and appearance criteria.
 - 3. Scrub and rinse floor and remove residual color, dust and debris.
 - 4. All grinding and polishing passes shall be made in the same direction until the entire given area has been covered.
- D. New Construction Concrete Control Joints:
 - 1. Freshly Placed Uncured Concrete: After concrete grinding and polishing, clean concrete substrate of dirt, chalk, markings and saw cut debris with cleaning agent or process recommended by manufacturer.
- E. Sealer, Hardener and Densifier Application:
 - 1. Prior to application of product, substrate to be clean, dry and absorbent. Confirm surface absorbency with a light water spray. If surface does not wet uniformly, use appropriate surface preparation cleaner or mechanical process to remove remaining surface contaminants per manufacturer's recommendations.
 - 2. Calculate Target Coverage Rate: Variations in concrete quality, porosity, job conditions, temperature and relative humidity will affect coverage rates and drying times. Test a representative section of the substrate surface to calculate the target coverage rate, but not less than 200 sq. ft. per gallon.
 - 3. Apply material at specified coverage rate by means recommend by manufacturer. Apply sufficient product to wet the surface until rejection without producing puddles. Use a clean, soft bristle push broom, microfiber pad or other means recommended by manufacturer to spread the product and ensure uniform wetting, saturation and penetration of surfaces.
 - 4. If surfaces dry immediately or become sticky, increase rate of application and reapply product. Avoid excess material puddling.
 - 5. Before product dries and cures, immediately clean surfaces not intended to receive application of material.
 - 6. Allow treated surfaces to dry or cure for duration recommended by manufacturer for project conditions.
 - 7. Remove any dried powder residue using stiff broom, power sweeper, automatic scrubbing machine, and/or cleaning agent recommended by manufacturer. Avoid pads or brushes which may damage the floor finish.
- F. Sealer and Stain Inhibiter Application:
 - 1. Prior to application of product, surfaces to be clean, dry and absorbent. Use appropriate surface preparation cleaner or mechanical process to remove contaminants per manufacturer's recommendations.
 - 2. Calculate Target Coverage Rate: Variations in concrete quality, porosity, job conditions, temperature and relative humidity will affect coverage rates and drying times. Test a representative section of the substrate surface to calculate the target coverage rate per manufacturer's recommendations, but not less than 500 sq. ft. per gallon.
 - 3. Apply material at the specified coverage rate by means recommend by manufacturer to produce an even coat. Restrict spreading area of product to maintain wet edge and avoid drying and visible overlapping.
 - 4. Allow treated surfaces to dry or cure for duration recommended by manufacturer for project conditions.
 - 5. Per manufacturer's recommendations where required, once dry, burnish surface using a high-speed burnisher, or polishing pad for use on gloss finishes, to heat and fuse the material bond to increase durability and longevity. Surface temperatures immediately behind the burnisher must achieve 90.5 degrees Fahrenheit.

6. Repeat sealer and stain inhibitor material application and burnishing process between coats as necessary for specified gloss finish. Apply up to three coats maximum.
 7. Do not allow floor to be subjected to any forms of moisture, including mopping and wet foot traffic for 12 hours minimum.
- G. Testing:
1. Test with a properly calibrated abridged goniophotometry device in accordance with ASTM E 430.
 2. Record results on floor plan diagram. Readings shall be taken not less than 10' on center in field areas and within 1' of floor area perimeters.
 3. Results shall comply with specified system performance and appearance criteria.
 4. Rework areas not in compliance until acceptable results are achieved or otherwise approved by Owner.
- H. Joint Sealant Installation:
1. Clean concrete floor joints and substrate by means necessary to allow proper bonding and sufficient sealant material deposit.
 2. Install sealant material in control and expansion joints in compliance with Section 07 92 00.
 3. Install joint sealants to a depth flush with adjacent surfaces.
 4. Remove excess material and clean.

3.03 PROTECTION, REPAIR AND CLEANING

- A. Provide disposal of slurry, dust and debris in compliance with applicable codes.
- B. Remove debris and spatter from adjoining surfaces as necessary.
- C. Repair damages to surface caused by cleaning operation and construction activities per manufacturer's recommendations.
- D. Restrict areas to traffic, cover and provide protection as specified and per manufacturer's recommendations to prevent damage by other trades during project completion.
- E. Protect from elements, sweep, clean and maintain until project completion and Owner's acceptance of the work.
- F. Provide Owner's representative documentation for proper cleaning and maintenance.

3.04 NON CONFORMING WORK

- A. If O'Reilly does not accept defective or non-conforming Work, the contractor shall install, at Contractor's expense (09 65 00) Resilient Flooring and (09 65 13) Resilient Base and Accessories. A Change Order will be issued to reflect an appropriate reduction in the Contract Sum to reimburse Owner the expense of two years of VCT maintenance costs, if VCT installation is required.

END OF SECTION

SECTION 03 38 00

POST-TENSIONED SLABS-ON-GROUND

PART 1 – GENERAL

1.01 SUMMARY

- A. Provide post-tensioned slab-on-ground systems for building foundation structure.
 - 1. Structural post-tensioned footings, foundations, and retaining walls.
 - 2. Structural post-tensioned slabs-on-ground and beam systems.
- B. Tendon quantities shown in tabulated forms on drawings are for convenience of Contractor only and are not guaranteed. Verify amounts shown in plans and details.

1.02 SUBMITTALS

- A. Comply with Section 01 33 00.
- B. Manufacturer's Data: Upon request submit manufacturer's data, certifications and installation instruction for proprietary materials and items, including prestressing steel tendons, anchorage, coupling, coating, sheathing, and forming accessories, admixture, grout, patching, compounds, joint systems and others required for complete system.
- C. Laboratory Strength Test and Plant PTI Certification: Upon request submit 1 copy to Owner for all steel tendons, anchorage and couplings used, including certified mill test reports containing a minimum of the following:
 - 1. Heat number and identification.
 - 2. Standard chemical analysis for heat of steel.
 - 3. Ultimate tensile strength.
 - 4. Yield strength at 1% extension under load.
 - 5. Elongation at failure.
 - 6. Modulus of elasticity.
 - 7. Diameter and net area of the strand.
 - 8. Type of material (stress-relieved or low relaxation).
 - 9. Representative load-elongation curve for each size and grade of strand supplied.
- D. Jack Calibrations and Certifications: Calibration certificates for each jack and gauge used shall be available upon request. Test from an independent laboratory for each jack equipment and instrument used shall be conducted not more than 3 months prior to project stressing work.

1.03 QUALITY ASSURANCE

- A. Comply with governing codes and regulations. Provide products of acceptable manufacturers, which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions. The Special Inspector must witness stressing operations and must measure and document elongations.
- B. Standards: Comply with the provisions of the following specifications and standards, except as otherwise noted or specified, or as accepted or directed by the Engineer:
 - 1. PTI Manual of Standard Practice
 - 2. PTI Manual of Design and Construction of Post-Tensioned Slab-On-Ground
 - 3. PTI Construction and Maintenance Procedures Manual for Post-Tensioned Slab-On-Ground
 - 4. PTI Specifications for Unbonded Single Strand Tendons
 - 5. ACI 318 Building Code Requirements for Reinforced Concrete
 - 6. CRSI Manual of Standard Practice

1.04 TOLERANCES

- A. PTI and ACI Standards shall govern work except where specified differently.
- B. Concrete and Conventional Reinforcement: Refer to Section 03 30 00.
- C. Tendon Placing Tolerances:
 - 1. Vertical deviations of the tendon should be $\pm \frac{1}{2}$ inch for slabs 5-inches thick or less and $\pm 10\%$ of the slab thickness, not exceeding 1 inch for slabs greater than 5 inches. Vertical and horizontal placing tolerance for draped beam tendons is ± 1 inch. The vertical location of the anchorages should not vary more than 1 inch from the location shown on the foundation drawings if obstructions prevent it from being located exactly as shown.
 - 2. Horizontal deviations of up to 12 inches are allowed for slab tendons when required to avoid openings and penetrations and to meet the geometry of a particular slab provided that a smooth transition is provided and that proper coverage is maintained. A minimum radius curve of 5 feet should be used for $\frac{1}{2}$ inch diameter strand.
- D. Cover Requirements: The following minimum clear cover distances to the post-tension tendons and conventional reinforcing is required:
 - 1. Beams:
 - a. Top: 2 inches
 - b. Bottom: 3 inches
 - c. Sides: 2 inches
 - 2. Slabs:
 - a. Top: 1 inch
 - b. Bottom: 1 $\frac{1}{2}$ inch

1.05 FIELD TESTING

- A. Comply with Section 01 45 16 – Quality Control Procedures.
 - 1. Testing: Owner shall employ a qualified independent testing laboratory and / or inspector to perform quality control of testing specified.
- B. Concrete: Refer to Section 03 30 00 for requirements.
- C. Tendon Stressing Measurements:
 - 1. Preparation: Properly seat wedges on tendon ends prior to stressing operation. Place initial reference mark equally spaced on both ends of tendon from anchor. Mark should be clear and accurately measured. Reference tendon location and record dimension in orderly tabulated form.
 - 2. Gauge Pressure: Stress each tendon as specified and record jack gauge pressure and identify jack used. Record value on stressing record form. Never stress tendons to a gauge reading which is higher than specified by the equipment manufacturer's calibration chart for the size of tendon elongated.
 - 3. Measurements: Remove stressing device and measure the distance from the reference mark to the nearest $\frac{1}{8}$ " with the tendon tail straight. Record value on the stressing record form. Measured elongation should compare within $\pm 10\%$ of the calculated elongation. Discrepancies exceeding $\pm 10\%$ shall be resolved with the Engineer.
 - 4. All $\frac{1}{2}$ inch diameter tendons shall be post-tensioned to an initial force of 33,000 lbs. each. The post-tensioning shall not be applied until the concrete has attained a minimum compressive strength of 75% of the 28 day design strength of 2,500 psi minimum. Stressing should occur between 3 days and 10 days after concrete placement unless sufficient strength is not met. The initial stress shall provide a minimum 0.08 inches of elongation of the tendon length for every foot of tendon length unless otherwise specified by the manufacturer or approved by the Engineer.
 - 5. Tendon stressing shall conform to the following:
 - a. Maximum jacking stress: 0.80 fpu

- b. Maximum tendon stress immediately after anchoring: 74 fpu
- c. Maximum anchor stress immediately after anchoring: 0.70 fpu
- D. Recording:
 1. Use the stressing record form supplied by the post-tensioning material supplier or inspection company used to record actual elongations.
 2. The stressing record should contain the following information:
 - a. Project identification:
 - 1). Project location and address
 - 2). Name of Owner, Contractor, and Inspection Company.
 - 3). Designing Architect and Engineer
 - b. Date of stressing
 - c. Equipment identification:
 - 1). Serial number or other identifying number of the stressing jack and gauge.
 - 2). Required gauge pressure corresponding to the jacking force required for the tendon size provided per the calibration chart supplied by the post-tension supplier.
 - d. Name of operator.
 - e. Tendon identification mark and calculated elongation.
 - f. Measured elongation.
 - g. Any special data or remarks related with the stressing.
 3. Record the measurement and compare it with the calculated elongation.
 4. If the measured elongation falls within the allowable variance, move to the next tendon and continue the stressing operation.
 5. If the measurement elongations do not fall within the allowable variance, discontinue stressing, until the cause has been identified and a solution resolved. Check for possible causes of improper elongations. Consult post-tension material supplier and Engineer for recommendations.
 6. Inspection Company shall submit complete stressing record immediately to Engineer for review.

1.06 DEFINITIONS

- A. Non-corrosive Environments: Structural system areas not normally exposed to direct or indirect applications of de-icer chemicals, soils containing less than 0.06% sulfate, seawater, or in the immediate vicinity of coastal salty air and further defined as coastal areas with building code wind speeds are less than 80 mph.
- B. Corrosive Environments: Structural system areas exposed to direct or indirect applications of de-icer chemicals, soils containing equal to or more than 0.06% sulfate, seawater, or in the immediate vicinity of coastal salty air and further defined as coastal areas with building code wind speeds of 80 mph or greater.

1.07 HAZARD & SAFETY CONSIDERATIONS

- A. Comply with General Conditions, all applicable government safety regulations, and PTI recommendations for installation of slab penetration locations, stressing operations, and repair of post-tension system.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Forms, Form Coatings, Steel Reinforcement, Concrete Materials, Admixtures and Other Miscellaneous Materials: Refer to Section 03 30 00 for requirements.
- B. Pre-stressing Tendons:
 1. Tendons shall be ½ inch diameter, single strand unbonded conforming to ASTM A 416 and ASTM E328, Grade 270 (270,000 psi), 7-wire regular stress relieved or low

- relaxation strand, greased and sheathed with plastic sleeve. Variations in diameter measured across the crowns of wire shall be +0.026 inches maximum and -0.006 inches minimum of the nominal size. No strand joints or splices in any length of installed strand will be allowed.
2. Low relaxation strand shall be provided with a mill applied continuous permanent physical marking to permit field identification.
 3. Material shall be packaged at the source in a manner to prevent physical damage to the strand during transportation and protects the material from deleterious corrosion during transit and storage.
- C. Anchors and Couplings:
1. Tendon anchorages and coupling shall be designed to develop the static and dynamic strength requirements of 95% of the actual ultimate strength of the pre-stressing steel tested in an unbonded state without exceeding anticipated set and ASTM standards.
 2. Anchors shall be arranged so that the pre-stressing force in the tendons may be verified prior to removal of the stressing equipment. Fittings shall be provided to allow the complete grouting of all coupling components. Castings shall be nonporous and free of sand, blow holes, voids, and other defects.
 3. Wedge type anchorages, the wedge grippers shall be designed to preclude premature failure of the pre-stressing due to notch or pinching effects under the static and/or dynamic test load conditions stipulated for both stress relieved and low relaxation pre-stressing steel materials.
 4. Couplings shall only be used at locations specified on the drawings or approved by the Engineer. Couplings shall be coated with the same corrosive preventative coating used on the strand and shall be enclosed in sleeves, which permit necessary movements during stressing.
 5. Anchorages intended for use in corrosive environments shall include design features permitting a watertight connection of the sheathing to the anchorage, and watertight closing of the wedge cavity, for stressing and non-stressing (fixed) anchorages. Intermediate stressing anchorages shall be designed to permit complete watertight encapsulation of the pre-stressing steel.
- D. Sheathing: The tendon sheathing shall be made of a material with the following properties:
1. Sufficient strength to withstand unrepairable damage during fabrication, transport, installation, concrete placement and tensioning.
 2. Water-tightness over the entire sheathing length.
 3. Chemical stability, without embrittlement or softening over the anticipated exposure temperature range and the service life of the structure.
 4. Non-reactive with concrete, steel, and the tendon corrosion preventative coating.
 5. Minimum thickness of the sheathing used in normal (non-corrosive) environments shall not be less than 0.025 inches for medium and high density polyethylene or polypropylene. Sheathing thickness for tendons used in corrosive environments shall have not less than 0.040 inches of medium or high density polyethylene or polypropylene.
 6. Sheathing shall have an inside diameter at least 0.010 inches greater than the maximum diameter of the strand.
 7. For applications in corrosive environments, the sheathing shall be connected to all stressing, intermediate and fixed anchorages in a watertight fashion, thus providing a complete encapsulation of the pre-stressing steel.
 8. All damage or breaks in sheathing shall be repaired per manufacturer's recommendations, and approved by Engineer, to prevent tendon deterioration or contact with concrete.
- E. Corrosive Preventive Coating:
1. The corrosion preventative coating material shall have the following properties:
 - a. Provide corrosion protection to the pre-stressing steel.
 - b. Provide lubrication between the strand and the sheathing.

- c. Resist flow from the sheathing within the anticipated temperature range of the exposure.
 - d. Provide a continuous non-brittle film at the lowest anticipated temperature of exposure.
 - e. Chemically stable and non-reactive with the pre-stressing steel, the sheathing material, and the concrete.
2. The film shall be an organic coating with appropriate polar, moisture displacing and corrosion preventive additives.
 3. Minimum weight of coating material on the pre-stressing strand shall be not less than 2.5 pounds of coating material per 100 feet of 0.5 inch diameter strand, and 3.0 pounds of coating material per 100 feet of 0.6 inch diameter strand. The amount of coating material used shall be sufficient to ensure essentially complete filling the annular space between the strand and the sheathing. The coating shall extend over the entire tendon length.
 4. Test performance in accordance with PTI-Post-Tensioning Manual (Fifth Edition), Table 3.2.1 ASTM criteria and requirements shall be provided for the corrosion preventive coating material.
- F. Miscellaneous Connection Materials: Refer to Section 05 50 00 for requirements.
1. Steel Plate: ASTM A 283, Grade C.
 2. Steel Shapes: ASTM A 36.
 3. Anchor Bolts: ASTM A 307.
 4. High Strength Threaded Fasteners: ASTM A 324.
 5. Steel Finish: ASTM A 153 galvanizing for exposed steel; primed for non-exposed steel.
 6. Bearing Pads: Elastomeric or TFE to suit bearing stresses.

PART 3 – EXECUTION

3.01 GENERAL

- A. Install materials and systems in accordance with manufacturer's instructions and approved submittals. Install materials and systems in proper relation with adjacent construction and with uniform appearance. Coordinate with work of other sections.
- B. Comply with PTI standards, and as herein specified.
- C. Under slab utilities shall pass a minimum of 6" beneath stiffening beams where possible. Oversize sleeving is required for utilities, which must cross through the beams and shall only be provided with written approval from the Engineer.

3.02 FORM WORK, CONCRETE, & STANDARD REINFORCEMENT

- A. Installation of Concrete Forms, Form Coatings, Steel Reinforcement, Concrete Materials, Admixtures and Other Miscellaneous Materials: Refer Section 03 30 00 for requirements.

3.03 ANCHORAGES

- A. Stressing Anchorages:
 1. Stressing anchorages shall be installed perpendicular to the tendon axis. Curvature in the tendon profile shall not be closer than three (3) feet from the stressing anchorage.
 2. Stressing anchorages shall be attached to forms by either bolts, nails, or threaded pocket former fittings. The connections shall be sufficiently rigid to avoid accidental loosening due to construction traffic or during concrete placement. Minimum cover for the anchorage shall not be less than the minimum cover to the reinforcement at other locations in the structure.

3. Pocket formers used to provide a void form at stressing and intermediate stressing anchorages shall positively preclude intrusion of concrete or cement paste into the wedge cavity during concrete placement. The depth of the pocket former from the edge of the concrete to the face of the anchorage shall not be less than 1-½ inches for normal environments nor 2 inches for corrosive environments.
- B. Intermediate Anchorages:
1. Intermediate anchorages may be installed either embedded in concrete or bearing against the hardened concrete at the construction joint. In the latter case, the anchorage shall have a flat bearing side and the concrete bearing area shall be smooth and without ridges.
 2. When placing intermediate anchorages against already hardened concrete, special attention must be paid to the perpendicularity between the form and the tendon during tendon placement. This type of anchorage is not allowed in corrosive environments.
 3. Minimum cover shall conform to stressing anchorage requirements.
- C. Fixed Anchorages:
1. Fixed end anchorages shall be installed on the tendon at supplier's plant prior to shipment to project.
 2. For wedge type anchorages, the fixed end wedges shall be seated, with a load of not more than 80% of the minimum ultimate tensile strength of the tendon for stress relieved strand or for low relaxation strand. The seating load shall be sufficient to ensure adequate capacity of non-stressing anchorages.
 3. Fixed end anchorages shall be placed in the formwork at the locations shown on drawings and securely fastened to the reinforcing steel. Minimum cover shall conform to stressing anchorage requirements.
 4. Fixed end anchorages intended for use in corrosive environments shall be closed or capped at the wedge cavity side with a water-tight cover. This cover shall be shop installed after filling the void around the wedge grips with corrosion preventive coating material comparable to that used over tendon.

3.04 TENDONS

- A. Stressing:
1. Tendons shall be securely supported on chairs at 4'-6" on center maximum and tied at all intersections to prevent displacement during concrete placement.
 2. Hydraulic stressing rams used to stress unbonded single strand tendons shall be equipped with stressing grippers which will not notch the strand more severely than normal anchoring wedges.
 3. Stressing rams and gauges shall individually be identified and calibrated against known standards at intervals specified. Calibration certificates for each jack used shall be available upon request.
 4. Stressing of tendons and elongation measurements shall be made at each stressing location as specified under FIELD TESTING paragraph. Stress slow enough to allow the strand to overcome as much friction as possible prior to seating.
 5. Tendons greater than 100 feet in length shall be post-tensioned from each end.
- B. Finishing:
1. Trim excess tendon length as soon as possible after tendon tensioning and stressing records have been submitted and approved by Engineer. The tendon length protruding beyond the wedges after cutting shall be between 0.75 inches and 1.25 inches. The tendon may be cut by means of oxyacetylene cutting, abrasive wheel or hydraulic shears. In case of oxyacetylene cutting of the tendon, care shall be taken to avoid directing the flame toward the wedges.
 2. For tendons used in corrosive environments, the exposed strand and wedge areas shall be coated with the tendon coating material comparable to that used over the length of the tendon and a watertight cap shall be applied over the coated area.

Prior to installation of grout, the inside concrete surfaces of the pocket shall be coated or sprayed with a resin-bonding agent.

3. Clean pocket former recesses of any dirt, grit, oil or other materials affecting good bond of grout and concrete.
4. Stressing pockets shall be filled flush with 1 inch minimum thick cover of non-shrink grout attaining a minimum compressive strength equal to the concrete slab, as soon as practical after tendon cutting. Under no circumstances shall the grout used for pocket filling contain chlorides or other chemicals known to be deleterious to the pre-stressing steel.
5. Where cutting of the tail results in less than 1 inch of grout cover from the face of concrete, provide tendon tail caps or equivalent device that will result in a minimum of 1 inch cover of the exposed strand end, but in no case shall there be less than 1/8 inch grout cover.

3.05 JOINTS AND INSERTS

- A. Concrete Joints: Refer Section 03 30 00. Where sawed joints are provided, caution shall be taken to avoid cutting or damaging tendons.
- B. Inserts: Install pre-manufactured inserts, caps, fasteners, wedges, couplers, extensions and recess formers per manufacturer's recommendations and approved submittals.

END OF SECTION