Section 03300 – Cast-In-Place Concrete

1. General

1.1 Summary

A. This section addresses all supervision, labor, materials, and equipment in the work for furnishing and installing cast-in place concrete, including formwork, reinforcing, mix design, placement procedures, and finishes.

1) Cast-in-place concrete includes the following:

   (a) Foundations and footings

   (b) Slabs-on-grade

   (c) Walls

   (d) Structural Slabs

   (e) Beams

   (f) Control, and expansion and contraction joint devices associated with concrete work, including joint sealants

   (g) Equipment pads

   (h) Water stops, anchor bolts, and other embedded accessories

   (i) Topping slabs

   (j) Adhesive cartridge anchors

   (k) Grout

B. Related Sections

   01600 Materials and Equipment
   02300 Earthwork
   03400 Precast Concrete Valve Vaults
   03930 Concrete Rehabilitation
   03931 Concrete Protective Coatings
   05501 Anchor Bolts and Anchors
   07620 Sheet Metal Flashing and Trim
   07900 Joint Sealants
   08310 Hatches
   09900 Painting

1.2 Submittals

A. Submit shop drawings and manufacturer’s data in accordance with the provisions of Division I, General Provisions, and Section 01600 – Materials and Equipment.
1) Product data for proprietary materials and items, including reinforcement and forming accessories, fiber reinforcement, bonding and form release agents, patching compounds, water stops, joint systems, vapor barriers, curing compounds, dry-shake finish materials, and others if requested by OWNER.

2) Cementitious materials: Sources of cement and other supplementary cementitious materials. Indicate name and location of mill or quarry. Conformance to ASTM standards including chemical analysis and physical tests.

3) Aggregates: Conformance to ASTM Standards, including sieve analysis, mechanical properties, and deleterious substance content. Provide test results on coarse and fine aggregates for mortar bar expansion per ASTM C1260.

4) Admixtures: air-entraining, water reducing, high-range water reducing and other proposed admixtures. Product data including catalogue cut, technical data, storage requirements, product life, recommended dosage, temperature considerations, slump ranges, and conformity to ASTM standards. Provide certification from admixture manufacturers that chloride content complies with specification requirements.

5) Concrete mixes: For each formulation of concrete proposed for use, submit constituent quantities per cubic yard, water cementitious ratio, air content, concrete slump, type and manufacturer of cement, fly ash or ground granulated blast furnace slag as proposed. Provide either Paragraph (a) or (b) below, for each mix proposed.

(a) Standard deviation data for each proposed concrete mix based on statistical records. Provide the following for each strength data point used in the calculation of the standard deviation for determination of the minimum required average strength:

1. Date of sampling and name of testing laboratory.
2. Name of concrete batch plant.
3. Water cementitious ratio.
4. Slump of batch.
5. Air content of batch.
6. Compressive strengths of all cylinders tested at that age in that batch.
7. If available, temperature and unit weight of batch.
8. Provide data from projects not more strictly controlled than outlined in these specifications. Provide summary sheet showing all pertinent data and the computation of the standard deviation.

(b) Water cementitious ratio curve for concrete mixes based on laboratory tests.
Provide average cylinder strength test results at 7, 14, and 28 days for laboratory concrete mix designs.

(c) Laboratory tests, per ASTM C1260 or C1567, certifying aggregates combined in the design mix meet the alkali silica reactivity limits per this specification.

6) Shop drawings for reinforcement detailing fabricating, bending, and placing concrete reinforcement. Comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures" showing bar schedules, stirrup spacing, bent bar diagrams, and arrangement of concrete reinforcement. Include special reinforcing required for openings through concrete structures.

7) Welder's certification in accordance with AWS D1.4 when welding of reinforcement is indicated, specified, or approved.

8) Formwork

(a) Formwork drawings and documents showing details of form types, methods of form construction, erection and removal methods and sequences, location of form joints and form ties and clean out openings in wall and column forms and shoring, locations and details of formwork and shoring anchorages which are located in the final concrete structure, stripping criteria and reshoring procedures. The submittal shall include drawings that clearly indicate the construction loads (location, direction and magnitude) delivered to the structure due to the formwork, shoring, stripping and reshoring and other construction activities. Where formwork and shoring anchorages are located in the final structure, provide details of anchorage removal and patching of the demolished concrete zone.

(b) Review will be for appearance, performance and strength of the completed structure only. Approval by the OWNER will not relieve the CONTRACTOR of responsibility for the strength, safety or correctness of methods used the adequacy of equipment, or from carrying out the work as shown on the Contract Drawings and as specified herein.

9) Fiber reinforcement: Submit manufacturer's data for synthetic reinforcing fibers. Identify all placements that are to contain synthetic reinforcing fibers. The fiber length and amount of fibers per cubic yard to be used for each placement shall be noted. Submit two samples of synthetic reinforcing fibers.

1.3 Quality Assurance

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

1) American Concrete Institute ACI 301, "Specifications for Structural Concrete for Buildings."

2) American Concrete Institute ACI 318, "Building Code Requirements for Reinforced Concrete."
3) American Concrete Institute ACI 350, “Code Requirements for Environmental Engineering Concrete Structures”

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

B. Use only one source of cement and aggregates for the project.

C. The CONTRACTOR shall provide all forms and shoring. Design formwork in accordance with the requirements of ACI 301, ACI 318 and ACI 347. Comply with all applicable regulations and codes. Consider any special requirements due to the use of plasticized and/or retarded set concrete.

D. Concrete Testing Service: The OWNER will employ and pay for a qualified independent testing and inspection service to perform material evaluation tests and to evaluate concrete mixes. The testing service will provide all field testing and inspection services and related laboratory tests. Methods of testing shall comply with the latest applicable ASTM methods. The following items shall be tested to verify conformity with this Section.

1) Concrete placements - compressive strength (cylinders), compressive strength (cores), temperature, slump, and air content.

2) Other materials that may require field testing

E. All tests that fail to meet specified requirements shall be re-tested at the expense of the CONTRACTOR. The CONTRACTOR shall notify the OWNER’s testing agency and OWNER when work has been corrected and is ready for the re-test.

1.4 References

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only. The referenced publications shall be the current effective edition.

B. American Association of State Highway and Transportation Officials (AASHTO)

1) AASHTO M 182 – Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

C. American Concrete Institute International (ACI)

1) ACI 211.1 – Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete

2) ACI 232.2 – Use of Fly Ash in Concrete

3) ACI 233 – Slag Cement in Concrete and Mortar

4) ACI 301 – Specifications for Structural Concrete for Buildings

5) ACI 304 – Guide for Measuring, Mixing, Transporting and Placing Concrete
6) ACI 305 – Guide to Hot Weather Concreting
7) ACI 306 – Guide to Cold Weather Concreting
8) ACI 309 – Guide for Consolidation of Concrete
9) ACI 318 – Building Code Requirements for Structural Concrete and Commentary
10) ACI 347 – Guide to Formwork for Concrete
11) ACI 350 – Code Requirements for Environmental Engineering Concrete Structures and Commentary
12) ACI SP-66 – ACI Detailing Manual

D. APA - The Engineered Wood Association
1) Material grades and designations as specified

E. American Welding Society (AWS)
1) AWS D1.4 – Structural Welding Code – Reinforcing Steel

F. ASTM International (ASTM)
1) ASTM A615 – Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
2) ASTM A704 – Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
3) ASTM A706 – Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
4) ASTM A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
5) ASTM C1064 – Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
6) ASTM C1017 – Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
7) ASTM C1077 – Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
9) ASTM C1218 – Standard Test Method for Water-Soluble Chloride in Mortar and
Concrete


11) ASTM C143 – Standard Test Method for Slump of Hydraulic-Cement Concrete


13) ASTM C156 - Standard Test Method for Water Retention by Liquid Membrane-Forming Curing Compound for Concrete


16) ASTM C172 – Standard Practice for Sampling Freshly Mixed Concrete

17) ASTM C173 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

18) ASTM C192 – Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory

19) ASTM C231 – Standard Test Method for Air Content of Freshly Mixed Concrete by Pressure Method

20) ASTM C233 – Standard Test Method for Air-Entraining Admixtures for Concrete


22) ASTM C295 – Standard Guide for Petrographic Examination of Aggregates for Concrete

23) ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

24) ASTM C31 – Standard Practice for Making and Curing Concrete Test Specimens in the Field


26) ASTM C33 – Standard Specification for Concrete Aggregates


28) ASTM C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
29) ASTM C42 – Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

30) ASTM C494 – Standard Specification for Chemical Admixtures for Concrete


32) ASTM C596 – Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement

33) ASTM C618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete


35) ASTM C94 – Standard Specification for Ready-Mixed Concrete

36) ASTM C989 – Standard Specification for Slag Cement for Use in Concrete and Mortars

37) ASTM D1752 – Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction


39) ASTM E1155 – Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers

40) ASTM E 154 – Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover

41) ASTM E1745 – Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

42) ASTM E329 – Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

G. Concrete Reinforcing Steel Institute (CRSI)

   1) CRSI – Manual of Standard Practice

H. National Ready Mixed Concrete Association (NRMCA)

   1) Quality Control Manual, Section 3 - Certification of Ready Mixed Concrete Production Facilities.

I. U.S. Army Corps of Engineers (USACE)

   1) USACE CRD-C 572 – Corps of Engineers Specifications for Polyvinylchloride
Waterstops

2. Products

2.1 Form Materials

A. Forms, General

1) Make forms for cast-in-place concrete of wood, steel or other approved materials. Construct wood forms of sound lumber or plywood free from knotholes and loose knots. Construct steel forms to produce surfaces equivalent in smoothness and appearance to those produced by new plywood panels. Design and construct all forms to provide a flat, uniform concrete surface requiring no grinding, repairs, or finishing except as specified in Paragraphs 3.9 and 3.11.

B. Forms for Exposed Finish Concrete

1) Make forms for all exposed and non-submerged exterior and interior concrete of new and unused Plyform exterior grade plywood panels manufactured in compliance with the APA and bearing the APA trademark. Provide B grade or better veneer with High Density Overlay on all faces to be in contact with concrete. Design and construct all forms to provide a flat, uniform concrete surface requiring no grinding, repairs, or finishing except as specified in Paragraphs 3.9 and 3.11.

2) Provide rigid forms that will not deflect, move, or leak. Design forms to withstand the high hydraulic pressures resulting from rapid filling of the forms and heavy high frequency vibration of the concrete. Limit deflection to 1/400 of each component span. Lay out form joints in a uniform pattern.

3) Dress and match boards. Sand plywood smooth and fit adjacent panels with tight joints. Tape, gasket, plug, and/or caulk all joints and gaps in forms to provide watertight joints that will withstand placing pressures without exceeding specified deflection limit or creating surface patterns.

C. Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or another acceptable material. Provide lumber dressed on at least two edges and one side for tight fit.

D. Forms for Cylindrical Columns and Supports: Metal, glass-fiber-reinforced plastic, or paper or fiber tubes that will produce smooth surfaces without joint indications. Provide units with sufficient wall thickness to resist wet concrete loads without deformation.

E. Form Ties: Factory-fabricated, adjustable-length, removable or snap-off metal form ties designed to prevent form deflection and to prevent spalling of concrete upon removal. Provide units that will leave no metal closer than 1-1/2 inches to the plane of the exposed concrete surface.

1) Provide ties that, when removed, will leave holes not larger than 1 inch in diameter in the concrete surface.
2) For liquid retaining structures and exterior below grade walls, provide ties that have a steel waterstop tightly attached to each strut or that have a neoprene rubber washer on each strut.

3) Do not use common wire for form ties.

2.2 Reinforcing Materials

A. Reinforcing Bars: ASTM A615 Grade 60, deformed.

B. Reinforcing Bars required to be Field Bent or Welded: ASTM A706, deformed.

1) ASTM A615, Grade 60 may be substituted for ASTM A706 subject to the following:

   (a) The actual yield strength of the reinforcing steel based on mill tests does not exceed the specified yield strength by more than 18,000 psi. Retests not to exceed this value by more than an additional 3,000 psi.

   (b) The ratio of the actual ultimate tensile strength to the actual tensile yield strength of the reinforcement is not less than 1.25.

   (c) The carbon equivalency (CE) is 0.55 percent or less.


D. Welded Plain Bar Mats: ASTM A704 and ASTM A615 Grade 60 plain bars.


F. Supports for Reinforcement: 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 specifications.

   1) For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs. Precast concrete blocks may be used. Precast blocks shall have wired ties and shall be not less than 4 inches square when supporting reinforcement on ground. Precast concrete blocks shall have compressive strength equal to that of the surrounding concrete.

   2) For exposed-to-view concrete surfaces where legs of supports are in contact with forms, provide supports with legs that are protected by plastic (CRSI, Class 1) or stainless steel (CRSI, Class 2).

G. Tie Wires for Reinforcement: 16-gauge or heavier black annealed wire.

H. Fiber Reinforcement: 100 percent virgin polypropylene fibrillated fibers conforming to ASTM C1116. The fiber length and quantity for a specific concrete mix shall be in accordance with the manufacturer’s recommendations as approved by the Engineer.
2.3 Concrete Materials

A. Portland Cement: ASTM C 150, Type II.
   1) Use one brand of cement throughout Project unless otherwise acceptable to the OWNER.

B. Fly Ash: ASTM C618, Class F. If aggregates are proven to be susceptible to alkali-silica reactivity, fly ash may be used.

C. Ground Granulated Blast Furnace Slag: ASTM C989, Grade 100 or 120. If aggregates are proven to be susceptible to alkali-silica reactivity, fly ash may be used.

D. Aggregates: ASTM C 33 for normal weight concrete (Table 4 – Moderate Weathering), ASTM C330 for lightweight concrete and as specified. Provide aggregates from a single source for exposed concrete.
   1) For exposed exterior surfaces, do not use fine or coarse aggregates that contain substances that cause spalling.
   2) Local aggregates not complying with ASTM C 33 when normal weight aggregates are used or ASTM C330 when light weight aggregates are used that have been shown to produce concrete of adequate strength and durability by special tests or actual service may be used when acceptable to OWNER.
   3) The fine and coarse aggregates used shall not cause expansion of mortar bars greater than 0.1 percent in 16 days when tested in accordance with ASTM C1260 and using the cement proposed for the project. If aggregates proposed for use do not meet this requirement, then satisfy either (a) or (b). below.
      (a) Total equivalent alkali content of the cement used shall not exceed 0.60 percent as provided in the Optional Chemical Requirements of ASTM C150.
      (b) The fine and coarse aggregates used shall not cause expansion of mortar bars greater than 0.1 percent in 16 days when tested in accordance with ASTM C1567 and using the cement and fly ash or ground granulated blast furnace slag proposed for the project. The proportions of the cement-fly ash mix or cement-ground granulated blast furnace slag mix shall be the same as those proposed for the project.

E. Water: Potable water free of oil, acids, alkali, salts, chlorides (except those attributable to drinking water), organic matter, or other deleterious substances

F. Admixtures, General: Provide concrete admixtures that conform to ASTM C233 and that contain not more than 0.1 percent chloride ions.

G. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.

H. Water-Reducing Admixture: ASTM C 494, Type A.
I. High-Range Water-Reducing Admixture: ASTM C 494, Type F or Type G.

J. Water-Reducing, Accelerating Admixture: ASTM C 494, Type E.

K. Water-Reducing, Retarding Admixture: ASTM C 494, Type D.

2.4 Related Materials

A. Sand Cushion: Clean, manufactured or natural sand.

B. Vapor Retarder: Shall be ASTM E 1745. Provide vapor retarder that is resistant to deterioration when tested according to ASTM E 154, as follows:
   1) Polyethylene sheet not less than 8 mils thick.

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

D. Moisture-Retaining Cover: One of the following, complying with ASTM C 171.
   1) Waterproof paper.
   2) Polyethylene film.
   3) Polyethylene-coated burlap.

E. Liquid Membrane-Forming Curing Compound: Liquid Membrane-Forming Curing Compound: Compound conforming to ASTM C309, Type 1-D (clear or translucent with fugitive dye) and containing no wax, paraffin, or oil. Curing compounds shall be non-yellowing and have a unit moisture loss no greater than 0.55 kg/m2 at 72 hours applied at 200 sq. ft. gal as measured by ASTM C156. Curing compound shall comply with Federal, State and local VOC limits.

F. Water-Based Acrylic Membrane Curing Compound: ASTM C 309, Type I, Class B.
   1) Provide material that has a maximum volatile organic compound (VOC) rating of 350 g/L.

G. Bonding Agents: ASTM C 881, two-component, solvent-free, asbestos-free epoxy resin material suitable for use on dry or damp surfaces. Provide material type, grade, and class to suit Project requirements.


I. Floor Hardener: Floor hardener shall be a colorless aqueous solution containing zinc silicofluoride, magnesium silicofluoride, or sodium silicofluoride. These silicofluorides can be used individually or in combination. Proprietary hardeners may be used if approved by the OWNER.

J. Waterstops: Unless noted otherwise waterstops shall be 9" wide preformed polyvinyl chloride (PVC) waterstops which meet the requirements of the Corps of Engineers Specification CRD C-572 may be used. Joints shall be spliced by heat fusion or
adhesion in strict compliance with the manufacturer’s recommendations.


L. Non-Shrink Grout: Premixed compound consisting of noncorrosive, nonstaining, non-metallic aggregate, cement, water reducing and plasticizing agents; capable of developing minimum compressive strength of 2,400 psi in 48 hours and 7,000 psi in 28 days. The grout shall comply with ASTM C 1107 and have a minimum 30- minute working time.

2.5 Proportioning and Designing Mixes

A. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trial batch method, use an independent testing agency acceptable to OWNER for preparing and reporting proposed mix designs. Do not use the same testing agency for field quality control testing. The mix design shall meet the requirements of ACI 301 and ACI 350 and conform to the following:

1) Water retaining concrete: The concrete mix design shall obtain a minimum compressive strength of 5000 psi and shall be in accordance with the following properties:

   Water Cement Ratio  .4 maximum
   Slump  2 to 4 Inches (8” maximum if using HRWR)
   Coarse Aggregate  ASTM C33 - #57
   Total Cementitious Content  540 lb/ yd3
   Air Content  6% (+/- 1%)
   (Flyash or Slag may be included)

2) Slab-On-Soil: The concrete mix design shall obtain a minimum compressive strength of 5000 psi and shall be in accordance with the following properties:

   Water Cement Ratio  .45 maximum
   Slump  3 Inches (8” maximum if using HRWR)
   Coarse Aggregate  ASTM C33 - #67
   Total Cementitious Content  560 lb/ yd3
   Air Content  6% (+/- 1%)
   (Flyash or Slag may be included)

3) Other concrete: The concrete mix design shall obtain a minimum compressive strength as noted on the Contract Drawings and shall be in accordance with the requirements ACI 301 and ACI 350. Select Exposure Categories which represent the specific project conditions. The minimum cement contents shall be based in the aggregate sizes selected. Select the minimum compressive strength, cement type, water/cement ratio, air content and quantities of supplemental cementitious materials based on the required Exposure Class.
2.6 Admixtures

A. Use water-reducing admixture or high-range water-reducing admixture (superplasticizer) in concrete, as required, for placement and workability.

B. Use high-range water-reducing admixture in pumped concrete, concrete required to be water-tight and concrete with water-cement ratios below 0.50.

C. Use air-entraining admixture in all concrete unless otherwise indicated. Add air-entraining admixture at manufacturers prescribed rate such that the required entrained air content is provided at the point of placement. Provide the amount of entrained air in accordance with the exposure levels listed in ACI 301 and ACI 350 and based on the aggregate sizes provided. The tolerances on the actual entrained air levels shall be +/- 1 ½%.

D. Supplemental Cementitious Materials: Provide, as required, Flyash and/or ground granulated blast furnace slag. The maximum amounts of these materials shall be in accordance with ACI 301 and ACI 350 unless greater amounts are approved by the OWNER.

E. If aggregates are determined to be susceptible to alkali-silica reactivity, include flyash, slag or other ASR reducing admixtures in the proposed concrete mixes in order to mitigate the occurrence of future alkali-silica reactions.

2.7 Concrete Mixing

A. Ready-Mixed Concrete: Comply with requirements of ASTM C 94, and as specified.

1) Discharge shall be completed within 1 ½ hours after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates. When air temperature is between 85 deg F and 90 deg F, reduce the discharge time from 1-1/2 hours to 75 minutes, and when air temperature is above 90 deg F, reduce the discharge time to 60 minutes.

2) Concrete must be produced at a certified plant. No on-site batch processing will be permitted for all reinforced and unreinforced concrete.

3. Execution

3.1 General

A. Coordinate the installation of joint materials, vapor retarder/barrier, pipe penetrations, wall sleeves, hatches, and other related materials with placement of forms and reinforcing steel.

B. Slabs shall be poured monolithically. Reinforcing and forms shall be maintained wet prior to concrete placement.
3.2 Forms

A. General: Design, erect, support, brace, and maintain formwork to support vertical, lateral, static, and dynamic loads that might be applied until concrete structure can support such loads. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation, and position. Maintain formwork construction tolerances and surface irregularities complying with the following ACI 347 limits:

1) Provide Class A tolerances for concrete surfaces exposed to view. Permitted irregularities are 1/8" for both gradual and abrupt.

2) Provide Class C tolerances for other concrete surfaces. Permitted irregularities are 1/2" for gradual and 1/4" for abrupt.

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 the Work. Use selected materials to obtain required finishes. Solidly butt joints and provide backup at joints to prevent cement paste from leaking.

C. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like for easy removal.

D. Unless otherwise noted on the Contract Drawings provide a minimum 3/4-inch chamfer for top of wall and on all exposed corners and edges. For exterior top slab of pump station structure use 2-inch chamfer. Create chamfers using wood, metal, PVC, or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.

E. 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 items. Accurately place and securely support items built into forms.

F. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before placing concrete. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

3.3 Vapor Retarder/Vapor Barrier Installation

A. General: Place vapor retarder/barrier sheeting in position with longest dimension parallel with direction of pour. Provide under all slabs-on-grade, in accordance with the Contract Drawings.

B. Lap joints 6 inches and seal with manufacturers recommended mastic or pressure-sensitive tape.
3.4 Placing Reinforcement

A. General: Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars," for details and methods of reinforcement placement and supports and as specified.

1) Avoid cutting or puncturing vapor retarder/vapor barrier during reinforcement placement and concreting operations. Repair damages before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials that reduce or destroy bond with concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcing by metal chairs, plastic chairs, bolsters, and concrete Brick, as approved by the OWNER.

D. Place reinforcement to maintain minimum coverages as indicated for concrete protection. 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. Minimum concrete cover, unless noted otherwise:

1) Concrete cast against and permanently exposed to earth. 3 in.

2) Concrete surfaces exposed to sewage:

   (a) Elevated Slabs and Base Slabs 3 in.

   (b) Beams and Columns:

       (1) Stirrups, spirals and ties 2 ½ in.

       (2) Primary Reinforcement 3 in.

       (3) Walls 3 in.

3) Concrete exposed to earth, liquid, weather, or bearing on work mat or slabs supporting earth cover:

   (a) Elevated Slabs, Base Slabs and Footings 2 in.

   (b) Beams and Columns:

       (1) Stirrups, spirals and ties 2 in.

       (2) Primary Reinforcement 2 1/2 in.

       (3) Walls 2 in.

E. Minimum length of tension lap slices shall be in accordance with ACI 350 for Class B splice, unless otherwise noted on the Contract Drawings, but not less than 12 inches.
F. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces in accordance with ACI 350. The minimum lap splice length shall not be less than one spacing of cross wires plus 2 in or not less than 12 in, whichever is larger. Tie the spliced fabrics together with wire ties spaced not more than 24 inches on center and lace with wire of the same diameter as the welded wire fabric. Offset laps of adjoining widths to prevent continuous laps in either direction.

G. Reinforcing steel interfering with the location of other reinforcing steel, piping, conduits or embedded items may be moved within the specified tolerances or one bar diameter, whichever is greater. Obtain the approval of the OWNER if greater displacement of bars to avoid interference is needed. Do not cut reinforcement to install inserts, conduits, mechanical openings or other items without the prior approval of the OWNER.

H. Do not weld reinforcing steel bars either during fabrication or erection unless indicated on the Contract Drawings or as specified herein, or unless prior written approval has been obtained from the OWNER. Comply with AWS D1.4 when welding of reinforcement is shown on the Contract Drawings, specified, or approved.

I. Do not field bend reinforcing unless indicated or specifically authorized in writing by the OWNER. Cold-bend bars indicated or authorized to be field bent around the standard diameter spool specified in the CRSI. Do not heat bars. Closely inspect the reinforcing steel for breaks. Replace, repair by cutting out damaged bars and splicing new bars using coupling sleeves filled with ferrous material, or otherwise repair damaged reinforcing bars as directed by the OWNER at no additional cost to the OWNER. Do not bend reinforcement after it is embedded in concrete unless indicated on the Contract Drawings.

J. Where reinforcing dowels are required and the CONTRACTOR elects to not penetrate the forms for their installation, steel threaded reinforcing bar couplers shall be provided for dowel installation during subsequent concrete placements.

3.5 Joints

A. Locate all joints where indicated on the Contract Drawings.

B. Construction Joints

1) Locate and install construction joints so they do not impair strength or appearance of the structure, as shown by the Contract Drawings and as acceptable to the OWNER.

2) Construction joints shall be formed with a shear key which has a depth of 1/3 the concrete thickness. Reinforcing bars shall be continuous through the joint.

3) If joint pattern is not shown, provide wall joints not exceeding 18 ft. in either direction.

C. Use bonding agent on existing concrete surfaces that will be joined with fresh concrete.
D. Expansion Joints

1) Expansion joints shall be provided if shown on the Contract Drawings. The joint filler material shall be firmly placed against the face of the completed concrete work before the concrete of the adjoining portion is placed. Reinforcement or other embedded metal items bonded to the concrete shall not be permitted to extend continuously through any expansion joint unless shown otherwise on the Contract Drawings or approved by the OWNER’S Representative.

3.6 Installing Embedded Items

A. All sleeves, anchor bolts, pipe anchors, inserts and embedded items shall be placed in positions prior to concreting. All such items must be clearly located on the shop drawings and shall be approved by the OWNER’S Representative. The CONTRACTOR shall coordinate and verify all mechanical, electrical and architectural drawings for the location of sleeves, pipes, ducts and all other items. Anchor bolt threads shall be protected with a coat of grease before placing concrete, after which they shall be thoroughly cleaned, regreased and wrapped in burlap. All ferrous metal inserts shall be galvanized.

B. The CONTRACTOR shall hold all embedded items in position and alignment during placement of concrete using templates, supplementary supports, ties or other approved means. Such supports or hardware, which will remain permanently in the concrete, shall be evaluated for their effect in shield integrity and shall be documented by photographs.

C. No items made of aluminum are allowed to be embedded in concrete unless otherwise shown on Contract Drawings. Aluminum surfaces in contact with concrete shall be given a heavy coat of an alkali-resistant bituminous paint before installation. Aluminum surfaces to be embedded in concrete shall be given one coat of zinc chromate primer.

D. Correct all embedded items not installed in the location or alignment needed or displaced by concrete placement at no additional cost to the OWNER.

E. Post installed anchors may be set with epoxy adhesive in accordance with the manufacturer’s recommendations and with the OWNER’s approval.

3.7 Preparing Form Surfaces

A. General: Coat contact surfaces of forms with an approved, non-residual, low-VOC, form-coating compound before placing reinforcement.

B. Clean, repair, remove projecting nails and fill holes, and smooth protrusions on all form surfaces to be in contact with concrete before reuse. Do not reuse forms for exposed concrete unless a "like new" condition of the form is maintained that will produce surfaces equivalent in smoothness and appearance to those produced by new plywood panels.

C. Do not allow excess form-coating material to accumulate in forms or come into
contact with in-place concrete surfaces against which fresh concrete will be placed. Apply according to manufacturer's instructions.

1) Coat steel forms with a non-staining, rust-preventative material. Rust-stained steel formwork is not acceptable.

3.8 Concrete Placement

A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. Before placing structural reinforced concrete, the OWNER, or designee, will perform all inspections required by the Special Inspections Program and will approve all formwork and reinforcing steel installations prior to the commencement of concrete placement.

C. General: Comply with ACI 304 and as specified.

D. Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened sufficiently to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as specified. Deposit concrete to avoid segregation at its final location.

E. Pumping of concrete will be permitted. Use a mix design and aggregate sizes chosen for pumping and submit for approval. Do not use pipelines made of aluminum or aluminum alloy. When concrete is pumped, slump will be determined at point of truck discharge and air content will be determined at point of placement.

F. Placing Concrete in Forms

1) Deposit concrete in forms in horizontal layers no deeper than 24 inches 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.

2) Consolidate placed concrete by mechanical vibrating equipment. Use equipment and procedures for consolidation of concrete complying with ACI 309.

3) Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the machine. Place vibrators to rapidly penetrate placed layer and at least 6 inches 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 mix to segregate.

4) Before placing structural/reinforced concrete, OWNER will perform Special Inspections and approve forms and reinforcing for concrete placement.
G. Placing Concrete Slabs

1) Deposit and consolidate concrete slabs in a continuous operation until completing placement of a panel or section.

2) Consolidate concrete during placement operations so that concrete is thoroughly worked around reinforcement, other embedded items and into corners.

3) All concrete for the top most elevated floor slabs, with dry or wet space below, shall be placed in one monolithic placing operation so as to eliminate the need for joints in the slab unless otherwise approved by OWNER prior to placing concrete.

4) Bring slab surfaces to correct level with a straightedge and strike off. Use bull floats or darbies to smooth surface free of humps or hollows. Do not disturb slab surfaces prior to beginning finishing operations.

5) Maintain reinforcing in proper position on chairs during concrete placement.

H. Cold-Weather Placement

1) Comply with provisions of ACI 306 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

2) When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.

3) Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

4) Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise accepted in mix designs and specifically approved by the OWNER.

I. Hot-Weather Placement

1) When hot weather conditions exist that would impair quality and strength of concrete, place concrete complying with ACI 305 and as specified.

2) Cool ingredients before mixing to maintain concrete temperature at time of placement to below 90 deg F. Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is CONTRACTOR'S option.

3) Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.
4) Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without puddles or dry areas.

5) Use water-reducing retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions, as acceptable to the OWNER.

3.9 Finishing Formed Surfaces

A. Ordinary Surface Finish: Provide a rough-formed finish on formed concrete surfaces not exposed to view in the finished Work or concealed by other construction. This is the concrete surface having texture imparted by form-facing material used, with tie holes and defective areas repaired and patched, and fins and other projections exceeding 1/4 inch in height rubbed down or chipped off.

B. Rubbed Finish: Provide a smooth-formed finish on formed concrete surfaces exposed to view or to be covered with a coating material applied directly to concrete, or a covering material applied directly to concrete, such as waterproofing, damp-proofing, veneer plaster, painting, or another similar system. This is an as-cast concrete surface obtained with selected form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch defective areas with fins and other projections completely removed and smoothed.

3.10 Monolithic Slab Finishes

A. The flatness of all slab surfaces shall meet ASTM E 1155 flatness values Overall Ff =38 / Fl =25 and Local Ff =26 / Fl =17. Outdoor slabs shall be sloped to drain a minimum of 1/8 inch per foot.

B. Slab Finish Descriptions

1) Steel Trowel Finish: Finish by screeding and floating with straightedges to bring the surfaces to the elevations indicated. While the concrete is still green, but sufficiently hardened to bear a person's weight without deep imprint, the surface shall be wood floated to a true, even plane with no coarse aggregate visible. Apply sufficient pressure on the wood floats to bring moisture to the surface. After surface moisture has disappeared, hand steel trowel to produce a smooth, impervious surface, free from trowel marks. Trowel the surface again for the purpose of burnishing. The final troweling shall produce a ringing sound from the trowel. Do not use dry cement or additional water in troweling.

2) Wood Float Finish: Finish by screeding with straightedges to bring the surfaces to the elevations indicated. Use a wood float to compact and seal surface. Remove all laitance and leave a clean surface.

3) Light Broomed Finish: Steel trowel finish the concrete, as specified above but omit the final troweling and finish the surface by drawing a fine-hair broom lightly across the surface. Broom in the same direction and parallel to expansion joints, or in the case of inclined slabs, perpendicular to the slope, or except as directed otherwise.

4) Broomed Finish: Steel trowel finish the concrete, as specified above but omit the
final troweling. While the concrete is still soft enough, finish the surface with a stiff coarse fiber broom to produce the pattern and depth of scoring as approved by the OWNER.

C. Schedule of Slab Finishes

1) Concrete for exterior on stairs and other horizontal areas - Broomed finish, non-slip.
2) Concrete for interior walking surfaces excluding stairs - wood float finish.
3) Concrete for interior stairs - Light broomed finish, non-slip.
4) Concrete stairs, landings and platforms below normal water level in liquid retaining structures - Broomed finish, non-slip.
5) Tops of curbs and pads - Steel trowel finish.
6) Concrete on which liquids flow or are contained - Steel troweled finish.
7) Concrete slabs to be covered with grout - Broom finish as approved.

3.11 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 specified to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete Work.

B. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Contract Drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with diagrams or templates of manufacturer furnishing machines and equipment. Prior to placing concrete equipment pads or floor toppings, scrub existing concrete surface clean, remove oil and grease by chipping or grinding and roughen substrate concrete surface. The cleaned surface shall be rinsed with clean water and kept saturated for the 24-hour period immediately preceding the placement of the concrete/topping. Immediately before the concrete/topping is applied the concrete surface shall be coated with neat Portland cement slurry having the consistency of paint.

3.12 Concrete Curing And Protection

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. For cold weather placements, follow the guidelines of ACI 306 and for hot weather placements, follow the guidelines of ACI 305. In hot, dry, and windy weather protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply according to manufacturer's instructions after screeding and bull floating, but before floating and troweling.

B. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting; keep continuously moist for not less than 7
days.

1) Curing Methods: Cure concrete to retain moisture and maintain a temperature of at least 50 Degrees F at the concrete surface for a minimum of seven days after placement. Use the following curing methods as specified: Water Curing: Keep entire concrete surface wet by ponding, continuous sprinkling or covered with saturated burlap. Begin water curing as soon as concrete attains an initial set and maintain water curing 24 hours a day. Do not permit the surface of the concrete to dry out at any time during the curing period. Temperature of curing water shall be within 20 Degrees F of the concrete temperature.

2) Sheet Material Curing: Cover entire surface with sheet material. Anchor sheeting to prevent wind and air from lifting the sheeting or entrapping air under the sheet. Place and secure sheet as soon as initial concrete set occurs.

3) Liquid Membrane Curing: Apply over the entire concrete surface except as follows. Curing compound shall NOT be placed on any concrete surface where additional concrete or grout is to be placed, where concrete sealers or surface coatings are to be used, or where the concrete finish requires an integral floor product. Apply curing compound as soon as the free water on the surface has disappeared and no water sheen is visible, but not after the concrete is dry or when the curing compound can be absorbed into the concrete. Apply in compliance with the manufacturer's recommendations.

C. Specified applications of curing methods:

1) Slabs for Liquid Retaining Structures: Water curing only.

2) Slabs on Grade and Footings (not used to retain liquids): Water curing, sheet material curing or liquid membrane curing.

3) Structural Slabs (other than Liquid Retaining Structures): Water curing, sheet material curing or liquid membrane curing.

4) Horizontal Surfaces which will Receive Additional Concrete, Coatings, Grout or Other Material that Requires Bond to the substrate: Water curing.

5) Formed Surfaces: None if nonabsorbent forms are left in place seven days. Water curing if absorbent forms are used. Water curing if forms are removed prior to seven days. [Sheet cure or liquid membrane cure if forms are removed prior to seven days.] Exposed horizontal surfaces of formed walls or columns shall be water cured for seven days or until next placement of concrete is made.

6) Surfaces of Concrete Joints: Water curing or sheet material curing.

3.13 Removing Forms

A. General: Formwork not supporting weight of concrete, such as sides of beams, walls, columns, and similar parts of the work, may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete, provided concrete is sufficiently hard to not be damaged by form-removal operations, and provided curing
and protection operations are maintained.

B. Formwork supporting weight of concrete, such as beam soffits, joists, slabs, and other structural elements, may not be removed in less than 14 days or until concrete has attained at least 75 percent of design minimum 28-day compressive strength at 28 days. Determine potential compressive strength of in-place concrete by testing field-cured specimens representative of concrete location or members.

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

3.14 Reusing Forms

A. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-coating compound as specified for new formwork.

B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints. Align and secure joint to avoid offsets. Do not use patched forms for exposed concrete surfaces except as approved by the OWNER.

3.15 Floor Hardeners

A. After 28 days, minimum, concrete cure, apply chemical hardener in three applications to a minimum total coverage of the undiluted chemical of 100 sq ft per gallon and in accordance with manufacturer's recommendations.

B. During application, area shall be well ventilated. Precautions shall be taken when applying silicofluorides due to the toxicity of the salts.

C. Any compound that contacts glass or aluminum shall be immediately removed by flushing with clear water.

3.16 Concrete Surface Patching and Repairs

A. Allow the OWNER to inspect concrete surfaces immediately upon removal of forms.

B. As soon as the forms have been stripped and the concrete surfaces exposed: remove fins and other projections; fill recesses left by the removal of form ties; and repair surface defects which do not impair structural strength. Clean all exposed concrete surfaces and adjoining work stained by leakage of concrete.

C. Immediately after removal of forms remove tie cones and metal portions of ties. Fill holes promptly upon stripping using a dry-pack mortar.

D. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removing forms, when approved by the OWNER.

E. Mix dry-pack mortar, consisting of one part Portland cement to 2-1/2 parts fine
aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing.

1) Cut out honeycombs, rock pockets, voids over 1/4 inch in any dimension, and holes left by tie rods and bolts, down to solid concrete; but, in no case to a depth less than 1 inch. Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush-coat the area to be patched with bonding agent. Place patching mortar before bonding agent has dried.

2) For surfaces exposed to view, blend white Portland cement and standard Portland cement in accordance with ASTM C595 so that, when dry, patching mortar will match surrounding color. Provide test areas at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike-off slightly higher than surrounding surface.

F. Repairing Formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of the OWNER. Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning. Flush out form tie holes and fill with dry-pack mortar or precast cement cone plugs secured in place with bonding agent.

1) Repair concealed formed surfaces, where possible, containing defects that affect the concrete's durability. If defects cannot be repaired, to the OWNER’s satisfaction, remove and replace the concrete.

G. Repairing Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface tolerances specified for each surface and finish. Correct low and high areas as specified. Test unformed surfaces sloped to drain for trueness of slope and smoothness by using a template having the required slope.

1) Repair finished unformed surfaces containing defects that affect the concrete's durability. Surface defects include crazing and cracks in excess of 0.01-inch-wide or that penetrate to the reinforcement or completely through non-reinforced sections regardless of width, spalling, popouts, honeycombs, rock pockets, and other objectionable conditions.

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

3) Correct low areas in unformed surfaces during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete. Proprietary underlayment compounds may be used when approved by the OWNER.

H. Perform structural repairs with prior approval of the OWNER for method and procedure, using specified epoxy adhesive and mortar.

I. Repair methods not specified above may be used, subject to prior approval by the OWNER.
3.17 Quality Control Testing During Construction

A. General: The OWNER will employ an independent testing agency conforming to ASTM E329 to perform tests and to submit test reports.

B. Sampling and testing for quality control during concrete placement may include the following, as directed by the OWNER.

1) Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.

   (a) Slump: ASTM C 143; one test at point of discharge at the beginning of the pour for each day's pour and each type of concrete; then one additional test for each 5 trucks; and additional tests when concrete consistency seems to have changed.

   (b) Air Content: ASTM C 173, volumetric method for lightweight or normal weight concrete; ASTM C 231, pressure method for normal weight concrete; one test per truck for first 3 trucks and if satisfactory then every fifth truck for each day’s pour of each type of air-entrained concrete.

   (c) Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below, when 80 deg F and above, and one test for each set of compressive-strength specimens.

   (d) Compression Test Specimen: ASTM C 31 or ASTM 192; one set of four standard cylinders for each compressive-strength test, unless otherwise directed. Mold and store cylinders for laboratory-cured test specimens except when field-cured test specimens are required.

   (e) Compressive-Strength Tests: ASTM C 39; one set for each day's pour exceeding 5 cu. yd. plus additional sets for each 50-cu. yd. more than the first 25 cu. yd. of each concrete class placed in any one day; one specimen tested at 7 days, two specimens tested at 28 days, and one specimen retained in reserve for later testing if required.

2) When frequency of testing will provide fewer than five strength tests for a given class of concrete, conduct testing from at least five randomly selected batches or from each batch if fewer than five are used.

C. Test results will be reported in writing to the OWNER, ready-mix producer, and the CONTRACTOR within 24 hours after tests. Reports of compressive strength tests shall contain the Project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day tests and 28-day tests.

D. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.
E. **Additional Tests:** The testing agency will make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by the OWNER. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed and approved by the OWNER.

3.18 **Field Control**

A. The OWNER may have cores taken from any questionable area in the concrete work such as construction joints and other locations as required for determination of concrete quality. The results of tests on such cores shall be the basis for acceptance, rejection or determining the continuation of concrete work. The right of the OWNER to take such cores shall not be construed as creating any obligation to take such cores, and not exercising this right to do so shall not relieve the CONTRACTOR from meeting the requirements of these Specifications.

B. Cooperate in obtaining cores by allowing free access to the work and permitting the use of ladders, scaffolding and such incidental equipment as may be required. Repair all core holes with an approved concrete repair mortar. The work of cutting, testing and repairing the cores will be at the expense of the CONTRACTOR if defective work is uncovered. If no defective work is found, such cost will be at the expense of the OWNER.

3.19 **Failure to Meet Requirements**

A. Should the strengths shown by the test specimens made and tested in compliance with the previous provisions fall below the specified compressive strengths, the OWNER may require changes in proportions or materials, or both, to apply to the remainder of the work. Furthermore, the OWNER may require additional curing on those portions of the structure represented by the test specimens which fall below the specified compressive strengths. The cost of such additional curing shall be at no additional cost to the OWNER. In the event that such additional curing does not give the strength required, as evidenced by core and/or load tests, the OWNER may require strengthening or replacement of those portions of the structure which fail to develop the required strength. Coring and testing and/or load tests and any strengthening or concrete replacement required because strengths of test specimens are below that specified, shall be at no additional cost to the OWNER. In such cases of failure to meet strength requirements the CONTRACTOR and the OWNER shall confer to determine what adjustment, if any, can be made in compliance with Sections titled "Strength" and "Failure to Meet Strength Requirements" of ASTM C94.

END OF SECTION