

SECTION 03010 - CAST-IN-PLACE CONCRETE**1.0 GENERAL**

- 1.01 Related Documents: The General Provisions of the Contract, including the General and Supplementary General Conditions and General Requirements, apply to the work specified in this Section.
- 1.02 Description of Work: Forming, shoring, bracing and anchorage concrete reinforcement and accessories, cast-in-place concrete.
- 1.03 Work Installed, but Furnished Under Other Sections:
- A. Masonry accessories attached to formwork.
 - B. Metal fabrications attached to formwork.
 - C. Flashing rights attached to form work.
- 1.04 Related Work: Walks, and curbs, precast concrete.
- 1.05 Standards and Codes:
- A. ACI 301 Specification of Structural Concrete for Buildings.
 - B. ANSI/ASTM A-185 - Welded Steel Wire Fabric for Concrete Reinforcement.
 - C. ASTM A-615 - Deformed and Plain Billet-Steel for Concrete Reinforcement.
 - D. ASTM C-33 - Concrete Aggregates.
 - E. ASTM C-94 - Ready-Mixed Concrete.
 - F. ASTM C-150 - Portland cement
 - G. ASTM C-260 - Air Entraining Admixtures for Concrete.
 - H. ASTM C-309 - Liquid Membrane-Forming Compounds for Curing Concrete.
 - I. ASTM D-2103 - Polyethylene Film and Sheeting.
 - J. FS TT-C-800 - Curing Compound, Concrete, for New Surfaces.
 - K. ACI 318 "Building Code Requirements for Reinforced Concrete"
 - L. ACI 304 "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete"
 - M. ACI 311 "Recommended Practice for Concrete Inspection"
 - N. ACI 347 "Recommended Practice for Concrete Formwork"
 - O. AWS D1.4 "Structural Welding Code - Reinforcing Steel"
 - P. CRSI "Manual of Standard Practice"
 - Q. American Society for Testing Materials (ASTM): All ASTM standards shall apply where appropriate.
 - R. ASTM C494 - Water Reducing Admixtures.
 - S. American Concrete Institute (ACI) - All ACI standards and specifications shall apply where appropriate.
- 1.06 Tests:
- A. A recognized testing laboratory approved by the Architect shall design the mixes of concrete to be used and to test the compression specimens made during the placing of the concrete. No concreting shall start until the Contractor has received written notice from the laboratory that all designs required have been received and approved by the Architect.
 - B. Test specimens to determine compressive strength shall be taken by the Contractor and delivered to the testing laboratory by the Contractor, at his expense, and in accordance with procedures set forth in ASTM Standards C-31 and C-39. Cost of testing shall be at the expense of the Contractor.

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- C. There shall be four compression specimens made for each strength of concrete placed on any one day, and for each fifty yards of concrete, also at such other times as may be deemed necessary for the Architect. One cylinder shall be broken at seven days and two cylinders broken at twenty-eight days. The average of the two twenty-eight day "breaks" shall be used as the test result. One cylinder shall be retained by test laboratory and broken only when and if instructed by the Architect.
 - D. Concrete not meeting the strength requirements set forth herein shall be removed and replaced without additional cost to the Owner at the discretion of the Architect. Should strength results of any cylinder indicate that the concrete has not obtained specified strength, the spare cylinder shall also be tested to see if it passes the strength requirements. Should the spare cylinder fail to meet the strength requirements of the specifications, core-boring tests conforming to ASTM Standard C-42 shall be made. Should the core boring tests indicate the strength requirements of the concrete below that specified, load tests conforming to ACI Standard 318 shall be made. The Contractor shall pay any ASTM C-42 tests or load tests required by cylinder tests not reaching specified strength.
 - E. Laboratory test results shall be sent to the Architect, the Owner, and the Contractor.
- 1.07 All cast-in-place concrete work shown is governed by this Section. Concrete strength not otherwise designated shall be 3,000 psi, as determined by the use of ASTM C-31 and C-39. All precast concrete shall be 4,000 psi.
- 1.08 Quality Assurance:
- A. Workmanship - The Contractor is responsible for the correction of concrete work that does not conform to the specific requirements, including strength, tolerances, and finishes. Correct deficient concrete as directed by the Architect/Engineer. Should cylinders and cores indicate unacceptable concrete, load testing or removal and replacement of the concrete may be required at no cost to the Owner.
 - B. Concrete Testing Service - The Contractor shall employ, at his/her own expense, a testing laboratory experienced in design and testing of concrete materials and mixes to perform material evaluation tests, to design concrete mixes, and to perform strength tests associated with form removal. Testing agency shall meet the requirements of ASTM E-329.
 - C. The Contractor shall employ and pay an independent testing laboratory to perform the testing of the concrete during the process of the work. Allow free access to material stockpiles and facilities at all times. Tests, not specifically indicated to be done at the Owner's expense, including the retesting or rejected materials and installed work, shall be done at the Contractor's expense.
 - D. Welding of reinforcing steel shall be limited to welders whose competency has been treated according to standards of Structural Welding Code of American Welding Society.
- 1.09 Submittals:
- A. Shop Drawings - Concrete Reinforcement: Submit shop drawings and fabrication, bending and replacement of concrete reinforcement. Comply with ACI Manual 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures" showing bar schedules, stirrup spacing, diagrams of bent bars, and arrangement of reinforcement. Show location of construction joints planned.

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- B. Manufacturer's Data; Concrete, General: Submit manufacturer's product data, specifications with application and installation instructions for proprietary materials and items, including admixtures, bonding agents, waterstops, joint systems, chemical floor hardeners, and dry shake finish materials.
- C. Test reports specified in Paragraphs PROPORTIONING AND DESIGN OF MIXES, QUALITY CONTROL TESTING DURING CONSTRUCTION.

2.0 PRODUCTS**2.01 Form Materials:**

- A. Forms for Exposed Finish Concrete:
 - 1. Unless otherwise shown or specified, construct formwork for exposed concrete surfaces with plywood, metal, metal-framed plywood faced or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on drawings. Provide form material with sufficient thickness to withstand pressure of newly-placed concrete without bow or deflection.
 - 2. Use plywood complying with US Product Standard PS-I "B-B (Concrete Form) Plywood", Class I, Exterior Grade or better, mill oiled, and edge sealed, with each piece bearing legible trademark of an approved inspection agency.
- B. Forms for Unexposed Finish Concrete - Form concrete surfaces which will be unexposed in finished structure with plywood, lumber metal or other acceptable material. Provide lumber dressed on at least two edges and one side for tight fit.
- C. Form Coatings - Provide commercial formulation form-coating compounds that will not bond with, stain nor adversely affect concrete surfaces, and will not impair subsequent treatments of concrete surfaces to be cured with water or curing compound.

2.02 Reinforcing Materials:

- A. Reinforcing Bar - ASTM A-615, Grade 60. TSQP-S-632, Type 11, DET ASTM A3 All reinforcement bars, except #2, shall be deformed bars in conformance with ASTM A-305 latest edition. Bar sized #3 through #11 shall meet the requirements for ASTM A-615 latest edition with minimum yield point strength of 60,000 psi. Provide Shop Drawings.
- B. Galvanized Reinforcing Bar - ASTM A-53, hot-dip galvanized after fabrication and bending.
- C. Welded Wire Fabric -ASTM A-185, welded steel wire fabric. Slab reinforcement mesh shall be cold drawn wire made especially for concrete work. Mesh shall be 6 x 6 W1.4 x W1.4 for 4" slabs on grade and 6 x 6, W2.9 x W2.9 mesh at 6" slabs on grade. Welded wire fabric shall be in conformance with ASTM A-185 latest edition.
- D. Supports for Reinforcement -Provide supports for reinforcement including, bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcing bars and welded wire fabric in place. Use wire bar type supports complying with CRSI recommendations, unless otherwise indicated. Wood, brick and other devices will not be acceptable.
- E. Slabs-on grade -Use supports or horizontal runners where wetted base material will not support chair legs.

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- F. Exposed-to-view concrete surfaces - Where legs of support are in contact with forms, provide supports with legs which are hot-dip galvanized or plastic protected or stainless steel protected.

2.03 Concrete Materials:

- A. Portland Cement - ASTM C-150, as follows:
1. Provide Type I cement, except as otherwise indicated.
 2. Provide Type III cement for High-Early Strength concrete where shown or scheduled.
 3. Use only one brand of cement for each required type through-out the project, unless otherwise accepted by the Architect/ Engineer.
- B. Aggregates:
1. Maximum aggregate size shall not be larger than one-fifth of the narrowest dimension between sides of forms, one third of the depth of slabs, nor three-fourths of the minimum clear spacing between individual reinforcing bars or bundles of bars. Provide aggregates from one source of supply to ensure uniformity in color, size, and shape.
 2. Normal Weight Aggregates - ASTM C-33, and as herein specified. Local aggregates not complying with ASTM C-33 but which have shown by special test or actual service to produce concrete of adequate strength and durability may be used when acceptable to the Architect/Engineer.
 - a) Fine Aggregate - Clean, sharp, natural sand free from loam, clay, lumps or other deleterious substances.
 - b) Coarse Aggregate - Clean, uncoated, processed aggregate containing no clay, mud, loam, or foreign matter, as follows:
 - 1) Crushed stone, processed from natural rock or stone.
 - 2) Washed gravel, either natural or crushed. Use of pit or bank run gravel is not permitted.
 - c) Pea Gravel Aggregate- Conform to ASTM C-404, Size No. 8. C. Water: Clean, fresh, drinkable.
- C. Admixtures - Provide admixtures produced by established reputable manufacturers and use in compliance with the manufacturer's printed directions. Do not use admixtures which have not been incorporated and tested in accepted mixes, unless otherwise authorized in writing by the Architect/Engineer.
1. Air-Entraining Admixture - ASTM C-260.
 2. Water-Reducing Admixtures - ASTM C-494, Type A.
 3. Set-Control Admixture - ASTM C-494, as follows:
 - a) Type D, Water-reducing and Retarding.
 - b) Type E, Water-Reducing and Accelerating.
 4. Fly Ash - ASTM C-618, Class F.
 5. Calcium Chloride - Do not use calcium chloride in concrete.

2.04 Related Materials:

- A. Waterstops - Provide flat, dumbbell type or centerbulb type waterstops at construction joints and other joints as shown. Size to suit joints. Rubber or PVC waterstops, at Contractor's option, with rubber units complying with Corps of Engineers CRD-C513 and PVC units complying with CRD-C572.
- B. Preformed Expansion Joint Fillers - Fiber type conforming to ASTM D 1751 or Cork, ASTM D 1752, Type II.
- C. Joint Sealing Compound - See Division 7.
- D. Moisture Barrier - 10 mil. Visqueen vapor barrier or approved equal.
- E. Chemical Hardener - Colorless aqueous solution containing a blend of magnesium fluosilicate and zinc fluosilicate combines with a wetting agent, containing not less than 2 lbs. of fluosilicate per gal.

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- F. Curing Materials:
1. Absorptive Cover - Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 3.
 2. Moisture-Retaining Cover - One of the following, complying with ASTM C-171.
 - a) Waterproof paper.
 - b) Polyethylene film
 - c) Polyethylene-coated burlap.
 3. Membrane-Forming Curing Compound - ASTM C-309, Type 1.

2.05 Proportioning and Design of Mixes:

- A. General:
1. All concrete shall contain a minimum of 5-1/2 sacks of cement per cubic yard. Tremie concrete, where required; use minimum of 7 sacks of cement per cubic yard. Maximum water to cement ratio (w/c) shall be 0.55 regardless of compressive strength.
 2. All concrete not specifically designated shall be proportioned for a strength of 3,000 lbs., per sq. in. at 28 days of age.

B. Slump Limits:

<u>Type of Construction</u>	<u>Slump in Inches</u>	
	<u>Maximum</u>	<u>Minimum</u>
Reinforced foundation walls and footings	5	3
Slabs and beams	5	3
Reinforced columns	6	3
Masonry Grout	11	8

- C. Proportion mixes by either laboratory trial batch or field experience methods, using materials to be employed on the project for each class of concrete required, complying with ACI 211.1 for normal weight concrete and ACI 211.2 for structural light-weight concrete.
1. Field Experience Method - When field experience method is used to select concrete proportions, establish procedures as specified in ACI 301 and ACI 318. When proportioning by field experience method, furnish mix design and independent testing facility proof of standard deviation using materials, mix and products facility proposed.
 2. Laboratory Trial Method - When laboratory trial batches are used to select concrete proportions, prepare test specimens in accordance with ASTM C-39, as specified in ACI 301.
 - a) When proportioning by the trial batch method, furnish compressive strength developed at 7 days and 28 days, from not less than 2 test cylinders cast for each 7 and 28 day test, and for each design mix.
 - b) Establish a curve showing relationship between water cement ratio (or cement content) and compressive strength, with at least 3 points representing batches which produce strengths above and below that required. Use not less than 2 specimens tested at 28 days, or an earlier age when acceptable to the Architect/Engineer, to establish each point on the curve.
- D. Submit Testing Service reports to the Architect-Engineer of each proposed mix for each type of concrete at least 15 days prior to start of work. Do not begin concrete production until mix data have been reviewed by the Architect/Engineer.
- E. Admixtures:
1. Use air-entraining admixture in all concrete, unless other-wise indicated. Add air-entraining admixture at the manufacturer's prescribed rate to result in concrete at the point of placement having 4-1/2 percent entrained air with tolerance in either direction from this optimum of 1-1/2 percent.

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2. Use amounts of admixtures as recommended by the manufacturer for climatic conditions prevailing at the time of placing. Adjust quantities and types of admixtures as required to maintain quality control.
- F. Adjustment to Concrete Mixes: Mix design adjustment may be requested by the Contractor when characteristics of material, job conditions, weather, test results, or other circumstances warrant; at no additional cost to the Owner and as accepted by the Architect/Engineer before using in the work.
- G. Bending Bars - Standard bends for bars shall be of diameters and lengths specified in "Manual of Standard Practice for Detailing Reinforced Concrete Structures" ACI-315.
- H. Tie Wire - All reinforcing steel shall be firmly tied in place with not less than No. 18 Gauge wire.

3.0 EXECUTION**3.01 Forms:**

- A. Design of formwork for structural stability and sufficiency is the Contractor's responsibility.
- B. 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 the form work so concrete members and structures are of correct size, shape, alignment, elevation, and position.
- C. Construct forms complying with ACI 347, 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, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required in work. Use selected materials to obtain required finishes. Solidly butt joints and provide back-up joints to prevent leakage of cement paste.
- D. 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. 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, and recesses to prevent swelling and for easy removal.
- E. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Securely brace temporary openings and set tightly to forms to prevent loss of concrete mortar. Locate temporary openings on forms at inconspicuous locations.
- F. Chamfer exposed corners and edges 3/4 inches, unless other wise noted, using wood, metal, PVC, or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.
- G. Form Ties - Factory-fabricated, adjustable-length, removable, or snap-off metal form ties, designed to prevent for deflection, and to prevent Spalding concrete surfaces upon removal.
 1. Unless otherwise shown, provide ties so portion remaining within concrete after removal is at least 1-1/2" inside concrete.
 2. Unless otherwise shown, provide form ties which will not leave holes larger than 1" diameter in concrete surface.
- 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 items. Accurately place and securely support items built into forms.

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- 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. Re-tighten forms after concrete placement if required to eliminate mortar leaks.
- 3.02 Placing Reinforcement:
- A. Comply with the specified codes and standards, and Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars", for details and methods of reinforcement placement and supports, and as herein specified.
 - 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 by formwork, construction, or concrete placement operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as required.
 - D. Place reinforcement to obtain at least the minimum coverage 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. Do not place reinforcing bars more than 2" beyond the last leg of continuous bar support. Do not use supports as bases for runways for concrete conveying equipment and similar construction loads.
 - E. Install welded wire fabric in as long lengths as practicable. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset end laps in adjacent widths to prevent continuous laps in either direction.
 - F. Splice:
 - 1. Provide standard reinforcement splices by lapping ends, placing bars in contact, and tightly wire tying. Comply with requirements of ACI 318 for minimum lap of spliced bars. Comply with the requirements of AWS D1.4 for field welding. Prior to field welding, determine the weldability of reinforcing bars by a laboratory chemical analysis of steel. Only steel conforming to the chemical requirements specified in AWS D1.4 may be welded.
 - 2. Mechanical butt splicing using exothermic welding processes and high-strength steel sleeves which develop the same values of strength shall be used for size no. 11 bars in columns. Comply with manufacturer's directions of preparation of bars and installation procedures. All other size column bars may be lap sliced.
- 3.03 Joints:
- A. Construction Joints - Locate and install construction joints, which are not shown on the drawings, so as not to impair the strength and appearance of the structure, as acceptable to the Architect/Engineer.
 - B. Provide keyways at least 1-1/2" deep in all construction joints in walls, slabs and between walls and footings; accepted bulk heads designed for this purpose may be used for slabs.
 - C. Place construction joints perpendicular to the main reinforcement. Continue all reinforcement across construction joints unless shown or noted otherwise.
 - D. Waterstops - Provide waterstops in construction joints as shown on the drawings. Install waterstops to form a continuous diaphragm in each joint. Make provisions to support and protect waterstops during the progress of the work. Fabricate field joints in waterstops in accordance with manufacturer's printed instructions. Protect waterstop material from damage where it protrudes from any point.

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- E. Isolation Joints in Slabs-on-Ground - Construct isolation joints in slabs on ground at all points of contact between slabs on ground and vertical surfaces, such as column pedestals, foundation walls, grade beams and elsewhere as indicated.
 - F. Control Joints in Slabs-on-Ground: Construct control joints in slabs-on-ground to form panels of patterns as shown. Use inserts 1/4" wide x 1/5 to 1/4 of the slab depth, unless otherwise shown. Form control joints by inserting a pre-molded hardboard or fiber board strip into the fresh concrete until the top surface of the strip is flush with the slab surface. After the concrete has cured, remove inserts and clean groove of loose debris. Joint sealant material is specified in Division 7. Sawn joints are permitted.
- 3.04 Installation of Embedded Items:
- A. 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. Use setting drawings, diagrams, instruction, and directions provided by suppliers of the items to be attached.
 - B. Edge Forms and Screed Strips for Slabs - Set edge forms or bulk heads and intermediate screed strips for slabs to obtain the required elevations and contours in the finished slab surface. Provide and secure units sufficiently strong to support the types of screed strips by the use of strike-off templates or accepted compacting type screeds.
- 3.05 Preparation of Form Surfaces:
- A. Coat the contact surfaces of forms with a form-coating compound before reinforcement is placed.
 - B. Thin form-coating compounds only with thinning agent of type, and in amount, and under conditions of the form-coating compound manufacturer's directions. Do not allow excess form-coating material to accumulate in the forms or to come into contact with concrete surfaces against which fresh concrete will be placed. Apply in compliance with manufacturer's instructions.
 - C. Coat steel forms with a non-staining, rust-preventative form oil or otherwise protect against rusting. Rust stained steel form work is not acceptable.
- 3.06 Concrete Mixing:
- A. General: Mix materials in an acceptable drum type batch machine mixer. For mixers of one cu. yd., or smaller capacity, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after all ingredients are in the mixer, before any part of the batch is released. For mixers of capacity larger than one cu. yd., increase the min. 1-1/2 minutes of mixing time by 15 seconds for each additional cu. yd., or fraction thereof. Provide a batch ticket for each batch discharged and used in the work, indicating the project identification name and number, date, mix type, mix time, quantity, and amount of water introduced.
 - B. Ready-Mix Concrete: Comply with the requirements of ASTM C 94, and as herein specified.
 - 1. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C 94 may be required. When the air temperature is between 85 degrees Fahrenheit and 90 degrees Fahrenheit, reduce the mixing and delivery time from 1-1/2 hours to 75 minutes. When the air temperature is above 90 degrees Fahrenheit, reduce the mixing and delivery time to 60 minutes.

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2. No additional water shall be added to concrete without the approval of the Architect/Engineer. Should additional water be required to obtain a slump as specified in this section for the type of concrete, the Contractor shall perform slump tests in accordance with ASTM C 143 to determine the actual slump of the concrete in the mixer. The Contractor may then add water, but in no case shall the additional water exceed 3 percent of the mix-design water content, nor shall the slump of the mix exceed the maximum slump specified for the type concrete. Slump tests and the addition of water to the mixer shall be completed within 15 minutes of the arrival of the mixer at the site. Additional water shall not be added to the mix after the mixer has been on the site longer than 15 minutes.
3. A delivery ticket showing truck number, date, and time that mixing was started shall be given to the Contractor's superintendent at the job site before placing the concrete from the truck mixer. At the job site the Contractor's Superintendent shall note on the delivery ticket the time of completion of the concrete placement from the truck and the general area of the structure in which the concrete was placed. A complete file of all delivery tickets shall be maintained and kept available at the job site until completion of the project.

3.07 Concrete Placement:

- A. Comply with ACI 304, and as herein specified.
- B. Pre-placement Inspection - Before placing concrete, inspect and complete the formwork installation, reinforcing steel, and items to be embedded or cast-in. Thoroughly wet wood forms immediately before placing concrete where form coatings are not used. Coordinate the installation of joint materials and moisture barriers with placement of forms and reinforcing steel.
- C. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously, provide construction joints as herein specified. Deposit concrete as nearly as practicable to its final location to avoid segregation due to re-handling or flowing. Maintain reinforcing in the proper position during concrete placement operations. Concreting shall be carried on at such a rate that the concrete is at all times plastic and flow steadily into spaces between reinforcing.
- D. Placing Concrete in Forms - Deposit concrete in forms in horizontal layers not deeper than 24" and in a manner to avoid inclined construction joints. Where replacement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints.
 1. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping. Use equipment and procedures for consolidation of concrete in accordance with the recommended practices of ACI 309, to suite the type of concrete and project conditions.
 2. Do not use vibrators to transport concrete inside of forms. 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 preceding layer. At each insertion limit the duration of vibration to the time necessary to consolidate the concrete and complete embedment of reinforcement and other embedded items without causing segregation of the mix.

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3. All concrete shall be thoroughly consolidated by suitable means during placement and shall be worked around reinforcement and embedded fixtures and into corners of forms. Minimum concrete wet cure time to be seven (7) days at 50 degrees minimum temperature. ACI 318-95 Section 5.11.1 / SBC Section 1906.5.1.
 - E. Placing Concrete Slabs - Deposit and consolidate concrete slabs in a continuous operation, within the limits of construction joints, until the placing of a panel or section is completed.
 - F. Bring slab surfaces to the correct level with a straightedge and strikeoff. Use bull floats or darbies to smooth the surface, leaving it free of humps or hollows. Do not sprinkle water on the plastic surface. Do not disturb the slab surfaces prior to beginning finishing operations.
 - G. Do not place concrete in an inundated excavation.
 - H. Cold Weather Placing - Protect concrete work from physical damage or reduced strength which could be caused by frost, freezing actions, or low temperatures, in compliance with ACI 306 and as here in specified. When air temperature has fallen to or is expected to fall below 40° F, uniformly heat all water and aggregates before mixing as required to obtain a concrete mixture temperature of 50° F at point of placement.
 - I. Hot Weather Placing:
 1. When hot weather conditions exist that would seriously impair quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.
 2. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90° F (32°C). 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.
 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 embedment in concrete.
 4. Wet forms thoroughly before placing concrete.
 5. Use water-reducing retarding admixture (Type D) when required by high temperatures, low humidity, or other adverse placing conditions.
 - J. The following concrete is prohibited:
 1. Partially hardened concrete.
 2. Contaminated concrete.
 3. Re-tempered concrete.
 4. Concrete that has been re-mixed after it has taken its initial set.
- 3.08 Finish of Formed Surfaces:
- A. Rough Form Finish - For formed concrete surfaces not exposed to-view in the finish 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, and fins and other projections exceeding 1/4" in height rubbed down or chipped off.
 - B. Smooth Form Finish - For 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, 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

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patch defective areas with fins or other projections completely removed and smoothed.

C. Smooth Rubbed Finish:

1. Provide smooth rubbed finish to scheduled concrete surfaces, which have received smooth form finish treatment, not later than one day after form removal.
2. Moisten concrete surfaces and rub with carborundum brick or other abrasive until a uniform color and texture is produced. Do not apply cement grout other than that created by the rubbing process.

D. Related Uniformed Surfaces: At tops of walls, horizontal off sets surfaces occurring adjacent to formed surfaces, strike-off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

3.09 Monolithic Slab Finishes:

A. Scratch Finish:

1. Apply scratch finish to monolithic slab surfaces that are to receive concrete floor topping or mortar setting beds for tile, Portland cement terrazzo, and other bonded applied cementitious finish flooring material, and as otherwise indicated.
2. After placing slabs, plane surface to a tolerance not exceeding 1/2" in 10' when tested with a 10' straightedge. Slope surfaces uniformly to drains where required. After leveling, roughen surface before final set, with stiff brushes, brooms, or rakes.

B. Float Finish:

1. Apply float finish to monolithic slab surfaces to receive trowel finish and other finishes as hereinafter specified.
2. After screening, consolidating, and leveling concrete slabs, do not work surface until ready for floating. Begin floating when surface water has disappeared or when concrete has stiffened sufficiently to permit operation of power-driven floats, or both. Consolidate surface with power-driven floats or by handfloating if area is small or inaccessible to power units. Check and level surface plane to a tolerance not exceeding 1/4" in 10' when tested with a 10' straightedge. Cut down high spots and fill low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat surface to a uniform, smooth, granular texture.

C. Trowel Finish:

1. Apply trowel finish to monolithic slab surfaces to be covered with resilient flooring, paint or other thin film finish coating system.
2. After floating begin first trowel finish operation using a power-driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and with a surface plane tolerance not exceeding 1/8" in 10' when tested with a 10' straightedge. Grind smooth surface defects which would telegraph through applied floor covering system.

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- D. Non-Slip Broom Finish:
1. Apply non-slip broom finish to exterior concrete platforms, steps and ramps, and elsewhere as indicated.
 2. Immediately after trowel finishing, slightly roughen concrete surface by brooming with fiber bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.
- E. Chemical-Hardener Finish - Apply chemical-hardener finish to interior concrete floors where indicated. Apply liquid chemical-hardener after complete curing and drying of the concrete surface. Dilute liquid hardener with water, and apply in 3 coats; first coat, 1/3 strength; second coat, 1/2 strength; third coat, 2/3 strength. Evenly apply each coat, and allow 24 hours for drying between coats.
1. Apply proprietary chemical hardeners, in accordance with manufacturer's printed instructions.
 2. After final coat of chemical-hardener solution is applied and dried, remove surplus hardener by scrubbing and mopping with water.
- F. Non-Slip Aggregate Finish: Apply non-slip aggregate finish where indicated.
1. After completion of float finishing, and before starting trowel finish, uniformly spread 25 lbs. of dampened non-slip aggregate per 100 sq. ft. of surface. Tamp aggregate flush with surface using a steel trowel, but do not force below surface. After broadcasting and tamping, apply trowel finishing as herein specified.
 2. After curing, lightly work surface with a steel wire brush, or an abrasive stone, and water to expose non-slip aggregate.
- 3.10 Concrete Curing and Protection:
- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
1. 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.
 2. 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, and by combination thereof, as herein specified.
1. Provide moisture curing by following methods.
 - a) Keep concrete surface continuously wet by covering with water.
 - b) Continuous water-fog spray.
 - c) Covering concrete surface with specified absorptive cover, thoroughly saturating cover with water and keeping
 2. Provide moisture-cover curing as follows: Cover concrete surfaces with moisture- retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3" and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
 3. Provide curing compound to slabs 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.

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- b) Do not use membrane curing compounds on surfaces which are to be covered with coating material applied directly to concrete, liquid floor hardener, waterproofing, damp-proofing, membrane roofing, flooring, painting, and other coatings and finish materials, unless otherwise acceptable to Architect.
 - C. Curing Formed Surfaces - Cure formed concrete surfaces, including undersides of beams, supported slabs and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.
 - D. Curing Unformed Surfaces:
 - 1. Cure unformed surfaces, such as slabs, floor topping, and other flat surfaces by application of appropriate curing compound.
 - 2. Final cure concrete surfaces to receive liquid floor hardener or finish flooring by use of moisture-retaining cover, unless otherwise directed.
- 3.11 Removal of Forms:
- A. 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° F. (10° C) 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, joints, slabs and other structural elements, may not be removed in less than 14 days and until concrete has attained design minimum 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.
- 3.12 Re-Use of Forms:
- A. Clean and repair surfaces of forms to be re-used in 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 form work.
 - 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 acceptable to Architect.
- 3.13 Miscellaneous Concrete Items:
- A. Filling-In: Fill-in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place, and cure concrete as herein specified, to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete work.
 - B. Equipment Bases and Foundations: Provide machine and equipment bases and foundations, as shown on drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.

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- A. **Patching Defective Areas:**
 - 1. Repair and patch defective areas with cement mortar immediately after removal of forms, when acceptable to Architect.
 - 2. Cut out honeycomb, rock pockets, voids over 1/4" in any dimension, 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. Thoroughly clean, dampen with water and brush-coat the area to be patched with specified bonding agent. Place patching mortar after bonding compound has dried.
- B. For exposed-to-view surfaces, blend white Portland cement and standard Portland cement so that, when dry, patching mortar will match color surrounding. Provide test areas at in- conspicuous location to verify mixture and color match before proceeding with patching. Compact mortar in place, and strike-off slightly higher than the surrounding surface.
- C. Repair of Formed Surfaces - Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of Architect. Surface defects, as such, include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets; fins and other projections that cannot be removed by cleaning. Flush out form tie holes, fill with dry pack mortar, or precast cement cone plugs secured in place with bonding agent.
- D. Repair concealed formed surfaces, where possible, that contain defects that affect the durability of concrete. If defects cannot be repaired, remove and replace concrete.
- E. Repair of Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface plane to tolerances specified for each surface and finish. Correct low and high areas as herein specified. Test unformed surfaces sloped to drain for trueness of slope, in addition to smoothness, using a template having required slope.
- F. Repair finished unformed surfaces that contain defects which affect durability of concrete. Surface defects, as such, include crazing, cracks in excess of 0.01" wide or which penetrate to reinforcement or completely through non-reinforced sections regardless of width, spalling, pop-outs, honeycomb, rock pockets, and other objectionable conditions.
- G. Correct high areas in unformed surfaces by grinding, after concrete has cured at least 14 days.
- H. Correct low areas in unformed surfaces during, or immediately after completion of surface finishing operations by cutting out low areas and replacing with fresh concrete. Finish repaired areas to blend into adjacent concrete. Proprietary patching compounds may be used when acceptable to Architect. Repair defective areas, except random cracks and single holes not exceeding in diameter, by cutting out and replacing with fresh concrete. Remove defective areas to sound concrete with clean, square cuts and expose reinforcing steel with at least 3/4" clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding compound. Mix patching concrete of same materials to provide concrete of same type or class as original concrete. Place, compact and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
- I. Repair isolated random cracks and single holes not over 1" in diameter by dry-pack method. Groove top of cracks and cut-out holes to sound concrete and clean of duct, dirt and loose particles. Dampen cleaned concrete surfaces and apply bonding

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compound. Mix dry-pack, 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. Place dry pack after bonding compound has dried. Compact dry-pack mixture in place, and finish to match adjacent concrete. Keep patched area continuously moist for not less than 72 hours.

- J. Use epoxy-based mortar for structural repairs, where directed by Architect.
- K. Repair methods not specified above may be used, subject to acceptance of Architect.

3.15 Quality Control Testing During Construction:

- A. The Contractor shall employ a testing laboratory approved by Architect/Engineer to perform other tests and to submit test reports. Sampling and testing for quality control during placement of concrete shall include the following, as directed by Architect.
Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
 1. Slump - ASTM C 143; one test for each concrete load at point of discharge; and one test for each set of compressive strength test specimens.
 2. Concrete Temperature - Test hourly when air temperature is 40°F (4°C) and below, and when 80°F (27°C) and above; and each time a set of compression test specimens made.
 3. Compression Test Specimen: ASTM C-31; one set of 4 standard cylinders for each compressive strength test, unless other wise directed. Mold and store cylinders for laboratory cured test specimens except when field cure test specimens are required.
 4. Compressive Strength Tests: ASTM C-39; one set for each 50 cu. yds. or fraction thereof, of each concrete class placed in any one day or for each 5,000 sq. ft. of surface area placed; 1 specimen tested at 7 days, 2 specimens tested at 28 days, and 1 specimen retained in reserve for later testing if required.
 - a) When strength of field-cured cylinders is less than 85% of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.
 - b) Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength, and no individual strength test result falls below specified compressive by more than 500 psi.
- B. Test results will be reported in writing to Architect and Contractor on same day that tests are made. 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.
- C. Additional Tests - The testing service 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 Architect. Testing service may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed. Contractor shall pay for such tests conducted, and any other additional testing as may be required, when unacceptable concrete is verified. **(END OF SECTION 03010)**