SECTION 03 30 53
(SHORT-FORM) CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Cast-in-place structural concrete.
   2. Slab on grade infill.
   3. Suspended slab infill on metal deck.
   4. Foundation wall infill.
   5. Equipment pads.
   6. Preparation of existing surfaces to receive concrete.
   7. Preparation of existing surface to received concrete topping.

1.2 RELATED REQUIREMENTS

A. Materials Testing and Inspection During Construction: Section 01 45 29, TESTING LABORATORY SERVICES.
B. Bituminous Dampproofing: Section 07 11 13, BITUMINOUS DAMPPROOFING.
C. Concrete Roads, Walks, and Similar Exterior Site Work: Section 32 05 23, CEMENT AND CONCRETE FOR EXTERIOR IMPROVEMENTS.

1.3 APPLICABLE PUBLICATIONS

A. Comply with references to extent specified in this Section.
B. American Concrete Institute (ACI):
   1. 117-15 - Tolerances for Concrete Construction, Materials and Commentary.
   2. 117M-10(R2015) - Tolerances for Concrete Construction, Materials and Commentary.
   3. 211.1-91(R2009) - Proportions for Normal, Heavyweight, and Mass Concrete.
   4. 211.2-98(R2004) - Selecting Proportions for Structural Lightweight Concrete.
   5. 301/310M-10 - Structural Concrete.
   6. 305.1-14 - Hot Weather Concreting.
   7. 306.1-90(R2002) - Cold Weather Concreting.
   8. 318/318M-14 - Building Code Requirements for Structural Concrete and SP-66-04-ACI Detailing Manual.
   9. 347-04 - Guide to Formwork for Concrete.
C. ASTM International(ASTM):

1. A615/A615M-15ae1 - Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
2. A996/A996M-15 - Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.
3. A1064/A1064M-15 - Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
4. C33/C33M-13 - Concrete Aggregates.
5. C39/C39M-15a - Compressive Strength of Cylindrical Concrete Specimens.
6. C94/C94M-15a - Ready-Mixed Concrete.
7. C143/C143M-15 - Slump of Hydraulic Cement Concrete.
8. C150/C150M-15 - Portland Cement.
9. C171-07 - Sheet Material for Curing Concrete.
10. C192/C192M-15 - Making and Curing Concrete Test Specimens in the Laboratory.
11. C219-14a - Terminology Relating to Hydraulic Cement.
12. C260/C260M-10a - Air-Entraining Admixtures for Concrete.
13. C330/C330M-14 - Lightweight Aggregates for Structural Concrete.
14. C494/C494M-15 - Chemical Admixtures for Concrete.
15. C618-15 - Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
16. C881/C881M-14 - Epoxy-Resin-Base Bonding Systems for Concrete.
17. C989/C989M-14 - Slag Cement for Use in Concrete and Mortars.
18. C1240-15 - Silica Fume Used in Cementitious Mixtures.
19. D1751-04(2013el) - Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types).
20. E1155-14 - Determining FF Floor Flatness and FL Floor Levelness Numbers.
21. E1745-11 - Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs.

D. International Concrete Repair Institute:

1. 310.2R-2013 - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

1.4 SUBMITTALS

A. Submittal Procedures: Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Submittal Drawings:
   1. Large scale drawings of reinforcing steel.
C. Manufacturer's Literature and Data:
   1. Concrete Mix Design.
   2. Air-entraining admixture, chemical admixtures, and curing compounds.
   3. Indicate manufacturer's recommendation for each application.
D. Sustainable Construction Submittals:
   1. Recycled Content: Identify post-consumer and pre-consumer recycled content percentage by weight.
E. Certificates: Certify products comply with specifications.
   a. Each ready mix concrete batch delivered to site.

1.5 DELIVERY

A. Deliver each ready-mixed concrete batch with mix certification in duplicate according to ASTM C94/C94M.

1.6 WARRANTY

A. Construction Warranty: FAR clause 52.246-21, "Warranty of Construction."

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I or II.
B. Pozzolans:
   1. Fly Ash: ASTM C618, Class C or F including supplementary optional physical requirements.
   2. Slag: ASTM C989/C989M; // Grade 80, // Grade 100 // or // Grade 120 //.
   3. Silica Fume: ASTM C1240.
C. Coarse Aggregate: ASTM C33/C33M.
   1. Size 467 for footings and walls over 300 mm (12 inches) thick.
   2. Size 7 for coarse aggregate for applied topping and metal pan stair fill.
   3. Size 67 for other applications.
D. Fine Aggregate: ASTM C33/C33M.
E. Lightweight Aggregate for Structural Concrete: ASTM C330/C330M, Table 1.
F. Mixing Water: Fresh, clean, and potable.
G. Air-Entraining Admixture: ASTM C260/C260M.

H. Chemical Admixtures: ASTM C494/C494M.

I. Vapor Barrier: ASTM E1745, Class A with a minimum puncture resistance of 2200 g (3000 lbs.); minimum 0.38 mm (15 mil) thick.

J. Reinforcing Steel: ASTM A615/A615M or ASTM A996/A996M, deformed. See Structural Drawings for grade.

K. Forms: Wood, plywood, metal, or other materials, approved by Contracting Officer, of grade or type suitable to obtain type of finish specified.

1. Plywood: Exterior grade, free of defects and patches on contact surface.
2. Lumber: Sound, grade-marked, S4S stress graded softwood.
3. Form coating: As recommended by Contractor.

L. Expansion Joint Filler: ASTM D1751.

M. Sheet Materials for Curing Concrete: ASTM C171.

N. Abrasive Aggregates: Aluminum oxide grains or emery grits.

O. Liquid Densifier/Sealer: 100 percent active colorless aqueous siliconate solution.

P. Grout, Non-Shrinking: Premixed ferrous or non-ferrous. Grout to show no settlement or vertical drying shrinkage at 3 days. Compressive strength for grout, at least 18 MPa (2500 psi) at 3 days and 35 MPa (5000 psi) at 28 days.

2.2 ACCESSORIES

A. Bonding Agent: ASTM C 1059/C 1059M, Type II.

B. Structural Adhesive: ASTM C881, 2-component material suitable for use on dry or damp surfaces. Provide material Type, Grade, and Class to suit Project requirements.

C. Water Stops: Rubber base with self-healing properties. Expanding clay based products not acceptable.

2.3 CONCRETE MIXES

A. Design concrete mixes according to ASTM C94/C94M, Option C.

B. Compressive strength at 28 days: minimum 25 MPa (3,000 psi).

C. Submit mix design and results of compression tests to the Contracting Officer for his evaluation. Identify all materials, including admixtures, making-up the concrete.

D. Maximum Slump for Vibrated Concrete: 100 mm (4 inches) tested according to ASTM C143.

E. Cement and Water Factor (See Table I):

TABLE I - CEMENT AND WATER FACTORS FOR CONCRETE				
Concrete: Strength	Non-Air-Entrained		Air-Entrained	
Min. 28 Day Comp. Str. MPa (psi)	Min. Cement kg/cu. m (lbs./cu. yd.)	Max. Water Cement Ratio	Min. Cement kg/cu. m (lbs./cu. yd.)	Max. Water Cement Ratio
35 (5000)1,3	375 (630)	0.45	385 (650)	0.40
30 (4000)1,3	325 (550)	0.55	340 (570)	0.50
25 (3000)1,3	280 (470)	0.65	290 (490)	0.55
25 (3000)1,2	300 (500)	*	310 (520)	*

Footnotes:

1. If trial mixes are used, achieve a compressive strength 8.3 MPa (1 200 psi) in excess of f'c. For concrete strengths greater than 35 MPa (5,000 psi), achieve a compressive strength 9.7 MPa (1,400 psi) in excess of f’c.
2. Lightweight Structural Concrete: Pump mixes may require higher cement values as specified in ACI 318/318M.
3. For Concrete Exposed to High Sulfate Content Soils: Maximum water cement ratio is 0.44.

* Laboratory Determined according to ACI 211.1 for normal weight concrete or ACI 211.2 for lightweight structural concrete.

F. Air-entrainment as specified, and conform with the following for air content table:

TABLE II - TOTAL AIR CONTENT FOR VARIOUS SIZES OF COARSE AGGREGATES	
Nominal Maximum Size of Coarse Aggregate	Total Air Content, percent
10 mm (3/8 inches)	6 Moderate exposure; 7.5 severe exposure
13 mm (1/2 inches)	5.5 Moderate exposure; 7 severe exposure
19 mm (3/4 inches)	5 Moderate exposure; 6 severe exposure
25 mm (1 inches)	4.5 Moderate exposure; 6 severe exposure

TABLE II - TOTAL AIR CONTENT FOR VARIOUS SIZES OF COARSE AGGREGATES	
Nominal Maximum Size of Coarse Aggregate	Total Air Content, percent
40 mm (1 1/2 inches)	4.5 Moderate exposure; 5.5 severe exposure

2.4 BATCHING AND MIXING

A. Store, batch, and mix materials according to ASTM C94/C94M.
   1. Job-Mixed: Batch mix concrete in stationary mixers as specified in ASTM C94/C94M.
   2. Ready-Mixed Concrete: Comply with ASTM C94/C94M, except use of non-agitating equipment for transporting concrete to Site is not acceptable.
   3. Mixing Structural Lightweight Concrete: Charge mixer with 2/3 of total mixing water and total aggregate for each batch. Mix ingredients minimum 30 seconds in stationary mixer or minimum 10 revolutions at mixing speed in truck mixer. Add remaining mixing water and other ingredients and continue mixing. Above procedure may be modified as recommended by aggregate producer.
   4. When aggregate producer's instructions deviate from specifications, submit proposed resolution for Contracting Officer's Representative consideration.

PART 3 - EXECUTION

3.1 FORMWORK

A. Installation: Conform to ACI 347. Construct forms to obtain concrete of the shapes, dimensions and profiles indicated, with tight joints.
B. Design and construct forms to prevent bowing-out of forms between supports and to be removable without prying against or otherwise damaging fresh concrete.
C. When patching formed concrete, seal form edges against existing surface to prevent leakage; set forms so that patch is flush with adjacent surfaces.
D. Treating and Wetting: Treat or wet concrete contact surfaces:
   1. Coat plywood and lumber forms with non-staining form sealer.
   2. Wet wood forms thoroughly when they are not treated with form release agent.

3. Prevent water from accumulating and remaining within forms.
4. Clean and coat removable metal forms with light form oil before reinforcement is placed.
5. In hot weather, cool metal forms by thoroughly wetting with water just before placing concrete.
6. Prevent water from accumulating and remaining within forms.

E. Inserts, Sleeves, and Similar Items: Install flashing reglets, masonry ties, anchors, inserts, wires, hangers, sleeves, boxes for floor hinges, and other cast-in items specified in other Sections. Place where indicated, square, flush and secured to formwork.

F. Construction Tolerances - General: Install and maintain concrete formwork to assure completion of work within specified tolerances.

G. Adjust or replace completed work exceeding specified tolerances before placing concrete.

3.2 REINFORCEMENT

A. Install concrete reinforcement according to ACI 318 and ACI SP-66.

B. Support and securely tie reinforcing steel to prevent displacement during placing of concrete.

C. Drilling for Dowels in Existing Concrete: Use sharp bits, drill hole slightly oversize, fill with epoxy grout, inset the dowel, and remove excess epoxy.

3.3 VAPOR BARRIER

A. Except where membrane waterproofing is required, place interior concrete slabs on a continuous vapor barrier.

B. Lap joints 150 mm (6 inches) and seal with a compatible pressure-sensitive tape.

C. Patch punctures and tears.

3.4 PLACING CONCRETE

A. Remove water from excavations before concrete is placed. Remove hardened concrete, debris and other foreign materials from interior of forms, and from inside of mixing and conveying equipment. Obtain approval from Contracting Officer's Representative before placing concrete.

B. Install screeds at required elevations for concrete slabs.

C. Roughen and clean free from laitance, foreign matter, and loose particles before placing new concrete on existing concrete.

1. Blow-out areas with compressed air and immediately coat contact areas with adhesive in compliance with manufacturer's instructions.

D. Place structural concrete according to ACI 301 and ACI 318.

E. Convey concrete from mixer to final place of deposit by method that will prevent segregation or loss of ingredients. Do not deposit, in Work, concrete that has attained its initial set or has contained its water or cement more than 1 1/2 hours. Do not allow concrete to drop freely more than 1500 mm (5 feet) in unexposed work nor more than 900 mm (3 feet) in exposed work.

F. Place and consolidate concrete in horizontal layers not exceeding 300 mm (12 inches) in thickness. Consolidate concrete by spading, rodding, and mechanical vibrator. Do not secure vibrator to forms or reinforcement. Continuously vibrate during placement of concrete.

G. Concrete Fill in Stair Tread and Landing Pans: Coat steel with bonding agent and fill pans with concrete. Reinforce with 2 inch by 2 inch by 1.6 mm (0.06 inch) welded wire mesh at midpoint.

H. Hot Weather Concrete Placement: As recommended by ACI 305.1 to prevent adversely affecting properties and serviceability of hardened concrete.

I. Cold Weather Concrete Placement: As recommended by ACI 306.1, to prevent freezing of thin sections less than 300 mm (12 inches) and to permit concrete to gain strength properly.

1. Do not use calcium chloride without written approval from Contracting Officer's Representative.

3.5 TOLERANCES

A. Slab on Grade Finish Tolerance: Comply with ACI 117, FF-number and FL-number method.

1. Paragraph 4.8.3, Class A 3 mm (1/8 inches) for offset in form-work.
2. Table R4.8.4, "Flat" 6 mm (1/4 inch) in 3 m (10 feet) for slabs.

3.6 PROTECTION AND CURING

A. Protect exposed surfaces of concrete from premature drying, wash by rain or running water, wind, mechanical damage, and excessive hot or cold temperatures.

B. Curing Methods: Cure concrete with curing compound using wet method with sheets.

C. Formed Concrete Curing: Wet the tops and exposed portions of formed concrete and keep moist until forms are removed.

1. If forms are removed before 14 days after concrete is cast, install sheet curing materials as specified above.

D. Concrete Flatwork Curing:

1. Install sheet materials according to the manufacturer's instructions.
   a. When manufacturer's instructions deviate from specifications, submit proposed resolution for Contracting Officer's Representative consideration.

3.7 FORM REMOVAL

A. Maintain forms in place until concrete is self-supporting, with construction operation loads.

B. Remove fins, laitance and loose material from concrete surfaces when forms are removed. Repair honeycombs, rock pockets, sand runs, spalls, or otherwise damaged surfaces by patching with the same mix as concrete minus the coarse aggregates.

C. Finish to match adjacent surfaces.

3.8 FINISHES

A. Vertical and Overhead Surface Finishes:

1. Surfaces Concealed in Completed Construction: As-cast; no additional finishing required.
2. Surfaces Exposed in Unfinished Areas: As-cast; no additional finishing required.
   a. Mechanical rooms.
   b. Electrical rooms.
3. Surfaces Exposed to View Scheduled for Paint Finish: Remove fins, burrs and similar projections by mechanical means approved by Contracting Officer's Representative flush with adjacent surface. Lightly rub with fine abrasive stone or hone. Use ample amount of water during rubbing without working up a lather of mortar or changing texture of concrete.
4. Surfaces Exposed to View in Finished Areas: Grout finish, unless otherwise shown, for uniform color and smooth finish treated.
   a. Remove laitance, fins and burrs.
   b. Scrub concrete with wire brushes. Clean stained concrete surfaces with hone or stone.
   c. Apply grout composed of 1 part Portland cement and 1 part clean, fine sand (smaller than 600 micro-m (No. 30) sieve). Work grout

into surface of concrete with cork floats or fiber brushes until pits and honeycomb are filled.

d. After grout has hardened, but is still plastic, remove surplus grout with sponge rubber float and by rubbing with clean burlap.

e. In hot, dry weather fog spray surfaces with water to keep grout wet during setting period. Complete finished areas in same day. Confine limits of finished areas to natural breaks in wall surface. Do not leave grout on concrete surface overnight.

B. Slab Finishes:

1. Allow bleed water to evaporate before surface is finished. Do not sprinkle dry cement on surface to absorb water.

2. Scratch Finish: Rake or wire broom after partial setting slab surfaces to received bonded applied cementitious application, within 2 hours after placing, to roughen surface and provide permanent bond between base slab and applied cementitious materials.

3. Float Finish: Exterior ramps, interior stair treads, and platforms, both equipment pads, and slabs to receive non-cementitious materials, except as specified.

a. Screen and float to smooth dense finish.

b. After first floating, while surface is still soft, check surfaces for alignment using straightedge or template. Correct high spots by cutting down with trowel or similar tool. Correct low spots by filling in with material same composition as floor finish. Remove any surface projections on floated finish by rubbing or dry grinding. Refloat slab to uniform sandy texture.

4. Steel Trowel Finish: Applied toppings, concrete surfaces to receive resilient floor covering or carpet, future floor roof and other monolithic concrete floor slabs exposed to view without other finish indicated or specified.

a. Delay final steel troweling to secure smooth, dense surface, usually when surface can no longer be dented by fingers. During final troweling, tilt steel trowel at slight angle and exert heavy pressure on trowel to compact cement paste and form dense, smooth surface.

b. Finished surface: Free from trowel marks. Uniform in texture and appearance.

5. Broom Finish: Finish exterior slabs, ramps, and stair treads with bristle brush moistened with clear water after surfaces have been floated.
6. Finished Slab Flatness (FF) and Levelness (FL):
   a. Slab on Grade: Specified overall value FF 25/FL 20. Minimum local value FF 17/FL 15.
   b. Test flatness and levelness according to ASTM E1155.

3.9 SURFACE TREATMENTS

A. Mix and apply the following surface treatments according to manufacturer's instructions.
   1. When manufacturer's instructions deviate from specifications, submit proposed resolution for Contracting Officer's Representative consideration.
B. Liquid Densifier/Sealer: Use for exposed concrete floors and concrete floors to receive carpeting except those specified to receive non-slip finish.
C. Slip Resistant Finish:
   1. Except where safety nosing and tread coverings are shown, apply abrasive aggregate to treads and platforms of concrete steps and stairs, and to surfaces of exterior concrete ramps and platforms.
      a. Broadcast aggregate uniformly over concrete surface. Trowel concrete surface to smooth dense finish. After curing, rub treated surface with abrasive brick and water sufficiently to slightly expose abrasive aggregate.

3.10 APPLIED TOPPING

A. Install concrete topping with thickness and strength shown with only enough water to ensure stiff, workable, plastic mix.
B. Continuously place applied topping until entire area is complete, struck off with straightedge, compact by rolling or tamping, float and steel trowel to hard smooth finish.

3.11 RESURFACING FLOORS

A. Remove existing flooring by abrasive blasting or grinding, in areas to receive resurfacing, to expose existing structural slab. Achieve a surface profile of 2 to 4 according to ICRI 310.2R for the condition found at Site.

B. Prepare exposed structural slab surface by cleaning, wetting, and applying adhesive according to manufacturer's instructions as specified in the flooring section.

3.12 FOUNDATION WALL INFILL

A. Install air-entrained concrete at foundation wall infill, as indicated.

B. Install expansion and contraction joints, waterstops, weep holes, reinforcement and railing sleeves, as indicated.

C. Finish exposed surfaces to match adjacent concrete surfaces, new or existing.

D. Place porous backfill, as indicated on Drawings.

END OF SECTION