SECTION 03300 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes.

B. Cast-in-place concrete includes the following:

1. Footings.
2. Foundation walls.
3. Slabs-on-grade.
4. Suspended slabs.
5. Concrete toppings.
6. Building frame members.
7. Building walls.
8. Equipment pads and bases.
9. Site perimeter walls, concrete filled bollards, and site structures.

1.2 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one of blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, or silica fume; subject to compliance with requirements.

1.3 SUBMITTALS

A. General: Submit the following according to Conditions of the Contract and Division 1 Specification Sections. Shop drawing review is only for conformance with the design concept of the project and compliance with the information given in the contract documents.

B. Product Data: For each type of manufactured material and product indicated.

C. Design Mixtures: For each concrete mixture. Include alternate mixtures designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

1. Mix design shall indicate the weight of each ingredient of the mixture, aggregate graduation, slump, air content, water/ cement ratio, admixtures, and 7 and 28 day compressive strength test results of trial mixes or acceptable record of field results.
2. Indicate amounts of mix water to be withheld for later addition at Project site.

D. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement. Comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures".

E. Formwork Shop Drawings: Prepared, signed and sealed by a professional engineer indicating fabrication and erection of forms of specific finished concrete surfaces. Show form construction including jointing, special form joints or reveals, location and pattern of form tie placement, and other items that affect exposed concrete visually. Show locations and detail construction joints for concrete work. Show locations of all embedded items. Drawings shall show all walls in elevation and in section.

1. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and installing and removing reshoring.

2. Review is for general applications and features only. Designing formwork and shoring sequence for structural stability and efficiency is Contractor's responsibility.

F. Welding Certificates: Copies of certificates for welding procedures and personnel.

G. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:

1. Aggregates Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.

H. Steel Reinforcement: From a qualified testing agency, indicating compliance with requirements.

I. Material Certificates: Signed by manufacturers certifying that each of the following items complies with requirements, including where applicable, compatibility with other subsequent materials and finishes:

1. Cementitious materials.
2. Admixtures.
3. Form materials and form-release agents.
4. Steel reinforcement and accessories.
5. Fiber reinforcement.
6. Waterstops.
7. Curing and sealing compounds.
8. Floor and slab treatments.
9. Bonding agents.
10. Adhesives.
11. Vapor retarders.
12. Semirigid joint filler.
13. Epoxy joint filler.
14. Joint-filler strips.
15. Repair materials.

J. Minutes of preinstallation conference.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed concrete Work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Professional Engineer Qualifications: A professional engineer who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for formwork and shoring and reshoring installations that are similar to those indicated for this Project in material, design, and extent.

C. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from the same manufacturer.

E. Welding: Qualify procedures and personnel according to AWS D1.4, "Structural Welding Code--Reinforcing Steel."

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

1. American Concrete Institute (ACI) 301-99, “Specifications for Structural Concrete for Buildings.”
2. ACI 117-90, “Specification for Tolerances for Concrete Construction and Materials”.
3. ACI 211.1-91, “Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.”
4. ACI 304R-00, “Guide for Measuring, Mixing, Transporting, and Placing Concrete.”
5. ACI 305R-99, “Hot Weather Concrete.”
6. ACI 306R-88, “Cold Weather Concrete.”
7. ACI 309R-96, “Guide for Consolidation of Concrete.”
8. ACI 318M-02, “Building Code Requirements for Reinforced Concrete.”
9. ACI 347-01, “Guide to Formwork for Concrete.”
10. Concrete Reinforcing Steel Institute (CRSI) “Manual of Standard Practice, 2001, 27th Edition”.

G. Preinstallation Conference: Conduct conference at the Project site to comply with requirements of Division 1 Section “Project Meetings” Comment #31 and the following:

1. At least 35 days prior to submitting design mixes, conduct a meeting to review detailed requirements for preparing concrete design mixes and to determine procedures for satisfactory concrete operations. Review requirements for submittals, status of coordinating work, and availability of materials. Establish preliminary work progress schedule and procedures for materials inspection, testing, and certifications. Require

representatives of each entity directly concerned with cast-in-place concrete to attend conference, including, but not limited to, the following:

a. Contractor's superintendent.
b. Agency responsible for concrete design mixes.
c. Agency responsible for field quality control.
d. Ready-mix concrete producer.
e. Primary admixture manufacturers.
f. Concrete subcontractor.
g. Formwork subcontractor.
h. Steel reinforcing installer subcontractor.
i. Quality Control Manager.
j. Contracting Officer's Representative (COR).

H. Place concrete after the placement of all forms, reinforcement, inserts, sleeves, and other embedments have been inspected and approved by the Contractor's superintendent and the Quality Control Manager and reviewed by the COR.

I. Place concrete only under the supervision of the Contractor's superintendent and the Quality Control Manager.

J. The Contractor is responsible for the establishment of a quality control program to manage forming, reinforcement, production, delivery, placement, compaction, finishing, curing, protection and patching of all concrete. Comply with the requirements specified in Section 01401.

K. Provide the Quality Control Manager and the COR with access to the site or to the plant to facilitate inspection of the reinforcement. Submit a schedule, showing the beginning and the duration of the shop fabrication, in sufficient time to allow for the proper inspection.

L. Provide the Quality Control Manager and the COR, with access to the concrete plant to facilitate inspection of concrete. Notify the Quality Control Manager when production of concrete is to commence and the plant location in sufficient time to allow for the proper inspection.

M. Inspection and testing will be performed by the Quality Control Manager in accordance with the requirements of this Section and Section 01401, Contractor's Quality Control.

N. Provide free access to the Work and cooperate with the appointed Quality Control Manager. Notify the QCM prior to the start of concrete work, at least 36 hours in advance. Provide a covered storage box on-site for the temporary storage of concrete cylinders.

O. Tests of the proposed cement, aggregates and other concrete ingredients will be performed to ensure conformance with the specified requirements.

P. The Quality Control Manager will make the concrete compressive test specimens and perform all the tests specified in this Section and Section 01401.

Q. The Quality Control Manager shall be the only entity authorized to allow the addition of any water to a concrete mix after batching.

R. The Quality Control Manger shall have the authority to reject concrete prior to or during placement for reasons of non-compliance with the Contract Documents. Rejected concrete will be promptly removed an replaced at no cost to the Owner.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store cement, aggregate, admixture, water, embedded items and reinforcing in a manner to prevent deterioration or intrusion of any foreign matter. Do not use damaged or deteriorated materials.

B. Deliver, store, and handle steel reinforcement to prevent bending and damage.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

A. Forms for Exposed Finish Concrete: Plywood, 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 or as shown on drawings.

B. 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.

C. Chamfer Strips: Wood, metal, PVC or rubber strips, 20 mm by 20 mm.

D. Form Release Agent: Provide commercially formulated form release agent with a maximum of 350 mg/l volatile organic compounds (VOCs) that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

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 40 mm to the plane of the exposed concrete surface.

1. Provide ties that, when removed, will leave holes not larger than 25 mm in diameter in the concrete surface.

2.2 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 420 (Grade 60), deformed. Reinforcing as indicated on the structural drawings to comply with the special ductility requirements of ACI-318M, paragraph 21.2.5, parts (a) and (b).

B. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.

C. Plain-Steel Wire: ASTM A 82, as drawn.

D. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

2.3 REINFORCEMENT ACCESSORIES

A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete, and as follows:

1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected or CRSI Class 2 stainless-steel bar supports.
2. For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs.

B. Joint Dowel Bars: Plain-Steel bars, ASTM A615M, Grade 420, cut bars true to length with ends square and free of burs.

C. Mechanical Splices and Connections: As indicated on Drawings.

2.4 CONCRETE MATERIALS

A. Portland Cement: ASTM C 150; Type V (High Sulfate Resistance) shall be used for all foundations and below grade concrete. Type II concrete shall be used for all other work.

1. Use one brand of cement throughout Project unless otherwise acceptable to Project Director.

B. Fly Ash: ASTM C 618, Class F.

C. Ground Granulated Blast-Furnace Slag (GGBF): ASTM C 989, Grade 100 or 120.

D. Normal-Weight Aggregate: ASTM C 33, uniformly graded, and as follows:

1. Coarse aggregate size for concrete in walls, columns, beams, and structural slabs shall not exceed 20 mm.
2. Coarse Aggregates: (a) General Use: 25 mm to 4.75 mm; (b) Walls, Columns, Beams, and Structural Slabs: 20 mm to 4.75 mm; (c) Tight Placement: 12.5 mm to 4.75 mm.
3. Fine Aggregates: Fineness modulus shall not be less than 2.3 nor more than 3.1.

4. Combined Aggregate Gradation: Well graded from coarsest to finest with not more than 18 percent and not less than 8 percent retained on an individual sieve, except that less than 8 percent may be retained on coarsest sieve, on the No. 50 (0.300 mm) sieve, and the No. 100 (0.150 mm) sieve.
5. Materials that contain particles that will discolor the surface shall not be used for any exposed concrete.
6. Provide aggregates from a single source for exposed concrete.
7. Do not use aggregates containing chloride ions in excess to the requirements of ACI for concrete construction in corrosive environments.

E. Lightweight Aggregate: ASTM C 330.

1. Nominal Maximum Aggregate Size: 10 mm.

F. Water: Potable and complying with ASTM C 94.

2.5 ADMIXTURES

A. General: Admixtures certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material and to be compatible with other admixtures and cementitious materials. Do not use admixtures containing calcium chloride. Accelerating admixtures shall not be used unless approved by the Quality Control Manager.

B. Air-Entraining Admixture: ASTM C 260, Type C.

C. Water-Reducing Admixture: ASTM C 494, Type A.

D. Retarding Admixture: ASTM C 494, Type B.

E. Accelerating (Non-Corrosive) Admixture: ASTM C 494, Type C.

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

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

H. High Range, Water-Reducing Admixture (Superplasticizer): ASTM C 494, Type F.

I. High Range, Water-Reducing and Retarding Admixture: ASTM C 494, Type G.

J. Corrosion-Inhibiting Admixture: Commercially formulated, calcium nitrite, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. DCI or DCI-S; W. R. Grace & Co., Construction Products Div.
b. Rheocrete CNI; Master Builders, Inc.

2.6 FIBER REINFORCEMENT

A. Synthetic Fiber: Fibrillated or monofilament polypropylene fibers engineered and designed for use in concrete, complying with ASTM C 1116, Type III, 12 to 25 mm long.

B. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

1. Fibrillated Fibers:

   a. Fibrasol F; Axim Concrete Technologies.
   b. Fibermesh; Fibermesh, Div. of Synthetic Industries.
   c. Forta; Forta Corporation.
   d. Grace Fibers; W. R. Grace & Co., Construction Products Div.

2. Monofilament Fibers:

   a. Fibrasol IIP; Axim Concrete Technologies.
   b. Fiberstrand 100; Euclid Chemical Co.
   c. Fibermix Stealth; Fibermesh, Div. of Synthetic Industries.
   d. Forta Mono; Forta Corporation.
   e. Grace MicroFiber; W. R. Grace & Co., Construction Products Div.

2.7 WATERSTOPS

A. Flexible Rubber Waterstops: CE CRD-C 513, for embedding in concrete to prevent passage of fluids through joints. Factory fabricated corners, intersections, and directional changes.

1. Profile: Flat, dumbbell with center bulb.
2. Dimensions: 150 mm by 10 mm thick.

B. Flexible PVC Waterstops: CE CRD-C 572, for embedding in concrete to prevent passage of fluids through joints. Factory fabricated corners, intersections, and directional changes.

1. Profile: Flat, dumbbell with center bulb.
2. Dimensions: 150 mm by 10 mm thick.

C. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Rubber Waterstops:

   a. Greenstreak.
   b. Progress Unlimited Inc.
   c. Westec Barrier Technologies; Div. of Western Textile Products, Inc.

2. PVC Waterstops:

a. Greenstreak.
b. Meadows: W. R. Meadows, Inc.
c. Murphy: Paul Murphy Plastics Co.
d. Progress Unlimited Inc.
e. Vinylex Corporation.
f. Sika Corporation.

D. Self-Expanding Strip Waterstops: Manufactured rectangular or trapezoidal strip, sodium bentonite or other hydrophylic material for adhesive bonding to concrete.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Volclay Waterstop-RX; Colloid Environmental Technologies Co.
b. Conseal CS-231; Concrete Sealants Inc.
c. Swellseal Joint; De Neef Construction Chemicals (U.S.) Inc.
d. Hydrotite; Greenstreak.

2.8 VAPOR RETARDERS

A. Vapor Retarder: Polyethylene sheet, ASTM D 4397, not less than 0.26 mm (10 mils) thick.

B. Granular Fill: Clean mixture of crushed stone or crushed or uncrushed gravel; ASTM D 448, Size 57, with 100 percent passing a 38-mm sieve and 0 to 5 percent passing a 2.36-mm (No. 8) sieve.

2.9 FLOOR AND SLAB TREATMENTS

A. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, non-glazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery with emery aggregate containing not less than 50 percent aluminum oxide and not less than 25 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

B. Penetrating Liquid Floor Treatment (Liquid Densifer/Sealer): For warehouses and garages. Chemically reactive, waterborne solution of inorganic silicate or siliconate materials and proprietary components; odorless; colorless; that penetrates, hardens, and densifies concrete surfaces, increases abrasion resistance, and provides a low sheen surface that is easy to clean and reduces the problem of tire mark removal.

C. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

1. Penetrating Liquid Floor Treatment:

a. Chemisil Plus; ChemMasters.
b. “Ashford Formula”, Curecrete Chemical Co.
c. “Euco Diamond Hard”, The Euclid Chemical Co.

2.10 CURING MATERIALS

A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete and exposed concrete slab surfaces for temporary protection from rapid moisture loss.

B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 300 g/sq. m (9 oz./sq. yd.) dry.

C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

D. Water: Potable.

E. Clear, Solvent-Borne, Membrane-Forming Curing Compound: ASTM C 309, Type1, Class B.

F. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1 Class B.

G. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

H. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

I. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

1. Evaporation Retarder:

   a. Spray-Film; ChemMasters.
   b. Sure Film (J-74); Dayton Superior.
   c. Confilm; Degussa Construction Chemicals.
   d. Eucobar; Euclid Chemical Co.
   e. E-Con; L&M Construction Chemicals, Inc.

2. Clear, Solvent-Borne, Membrane-Forming Curing Compound:

   a. Spray-Cure Clear; ChemMasters.
   b. General Purpose Cure & Seal (J-20UV); Dayton Superior.
   c. MasterKure N-Seal-HS; Degussa Construction Chemicals
   d. Diamond Clear; Euclid Chemical Co.
   e. Dress & Seal 30; L&M Construction Chemicals, Inc.

3. Clear, Waterborne, Membrane-Forming Curing Compound:

   a. Safe Cure Clear; ChemMasters.
   b. Day-Chem Rez Cure (J-11-W); Dayton Superior.
   c. Kure-N-Seal W; Degussa Construction Chemicals.
   d. Diamond Clear VOX; Euclid Chemical Co.

e. Dress & Seal WB 30; L&M Construction Chemicals, Inc.

4. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound:

a. Spray-Cure & Seal 25; ChemMasters.
b. Super Diamond Clear; Euclid Chemical Co.
c. Lumiseal Plus; L&M Construction Chemicals, Inc.

5. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound:

a. Polyseal WB; ChemMasters.
b. Super Diamond Clear VOX; Euclid Chemical Co.
c. Lumiseal WB Plus; L&M Construction Chemicals, Inc..

2.11 RELATED MATERIALS

A. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

B. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of type, class, and grade to suit requirements.

C. Dovetail Anchor Slots: Hot-dip galvanized steel sheet, not less than 0.85 mm (22 gage) thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

D. Reglets: Fabricate reglets of not less than 0.55 mm (26 gage) thick galvanized steel sheet. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.

E. Epoxy Joint Filler: For control and construction joints of slab-on-grade in warehouses, a two component, 100 percent solids, low-range tensile strength semi-rigid epoxy with a minimum shore D hardness 50 (ASTM D676) and elongation of 6 percent (ASTM D 2240). The epoxy joint filler shall be mixed and installed in strict accordance with the direction of manufacturer. The joint filler shall not be filled sooner than 90 days after slab placement.

F. Joint Sealant for Isolation Joint at Slab-on-Grade:

1. Eucolastic I (Urethane sealant): Use closed cell polyethylene backer rod.

2.12 REPAIR MATERIALS

A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 3 mm and that can be feathered at edges to match adjacent floor elevations.

1. Cement Binder: ASTM C 150, Portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.

2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 3 to 6 mm or coarse sand as recommended by underlayment manufacturer.
4. Compressive Strength: Not less than 30 MPa at 28 days when tested according to ASTM C 109/C 109M.

B. Repair Topping: Traffic-bearing, cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 6 mm.

1. Cement Binder: ASTM C 150, Portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 3 to 6 mm or coarse sand as recommended by topping manufacturer.
4. Compressive Strength: Not less than 40 MPa at 28 days when tested according to ASTM C 109/C 109M.

2.13 CONCRETE MIXES

A. Prepare design mixes for each type and strength of concrete determined by laboratory trial batch method as specified ACI 211.1, ACI 301 and ACI 318M. Use an independent testing agency acceptable to the Project Director for preparing and reporting proposed mix designs. Do not use the same testing agency for field quality control testing.

B. Submit written reports to the Project Director of each proposed mix prepared and sealed by a professional engineer for each class of concrete at least 15 days prior to start of Work. Do not begin concrete production until the Project Director has approved proposed mix designs.

C. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Limit use of fly ash and ground granulated blast furnace (GGBF) slag to not exceed 20 percent of cementitious content by weight.

D. Design mixes to provide normal weight concrete with properties as indicated herein unless indicated otherwise on the Structural Drawings.

1. Civil/Site and Perimeter Walls. Proportion normal-weight concrete mix as follows:

a. Compressive Strength (28 Days): 30 MPa minimum.
b. Maximum Slump: 125 mm.

2. Slab-on-Grade and Footings. Proportion normal-weight concrete mix as follows:

a. Compressive Strength (28 Days): 25 MPa minimum.

b. Maximum Slump: 125 mm.

3. Suspended Slabs and Building Frame Members: Proportion normal-weight concrete mix as follows:

   a. Maximum Slump: 125 mm.
   b. Maximum Slump for Concrete Containing High-Range, Water-Reducing Admixture: 200 mm after admixture is added to concrete with 50 mm to 75 mm slump.
   c. Compressive Strength (28 Days): 30 MPa minimum.

4. Footings and Foundations – 25 MPa

E. Water-Cementitious Materials Ratio: Provide concrete for following conditions with maximum water-cementitious materials (W/C) ratios as follows:

1. Unless noted otherwise: Maximum W/C = 0.50.
2. Maximum Water-Cementitious Materials Ratio: 0.45 for concrete subject moderate sulfate exposure (per ACI 318M Table 4.3.1) or required to have low water permeability or subject to freezing and thawing while moist.
3. Maximum Water-Cementitious Materials Ratio: 0.40 for concrete subject to severe or very severe sulfate exposure (per ACI 318M Table 4.3.1) or for corrosion protection of steel reinforcement in concrete exposed to chlorides from deicing chemicals, salt, saltwater, brackish water, seawater, or spray from these sources.

F. Limit water-soluble, chloride ion content in hardened concrete to 0.15 percent by weight of cement.

G. Synthetic Fiber: Uniformly disperse in concrete mix at manufacturer's recommended rate, but not less than 0.90 kg/m^3 (1.5 lb./cu. yd.).

H. Air Content: Use air-entraining admixtures in exterior exposed concrete unless otherwise indicated. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having total air content of 6 percent with a tolerance of plus or minus 1½ percent.

1. Do not air entrain concrete for trowel finished interior floors and suspended slabs.
2. Do not allow entrapped air content to exceed 3 percent.
3. Concrete exposed to sulfates shall be air-entrained.

I. Admixtures: Use admixtures according to manufacturers written instructions.

1. Use water-reducing admixture or high-range water-reducing admixture (superplasticizer) in concrete, as required, for placement and workability.
2. Use water-reducing and retarding admixtures when required by high temperatures, low humidity, or other adverse placement conditions.
3. Use high range water-reducing admixture in pumped concrete as required for pumpability and workability and concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.

4. Use corrosion-inhibiting admixture in concrete mixes where indicated. Corrosion inhibiting admixture is to be added at the Project site.

2.14 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.15 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94, and furnish batch ticket information.

1. When air temperature is between 30 deg C and 32 deg C, reduce mixing and delivery time from 90 minutes to 75 minutes, and when air temperature is above 32 deg C, reduce mixing and delivery time to 60 minutes.
2. Hand-Mixed Concrete: Hand mixed concrete is not allowed.

PART 3 - EXECUTION

3.1 FORMWORK

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301 and as shown on formwork shop drawings which have been reviewed by the Project Director, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until concrete structure can support such loads.

B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

C. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:

1. Class A, 3 mm.
2. Class B, 6 mm.
3. Class C, 13 mm.
4. Class D, 25 mm.

D. Construct forms tight enough to prevent loss of concrete mortar.

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

1. Do not use rust-stained steel form-facing material.

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

G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

H. Chamfer exterior corners and edges of permanently exposed concrete.

I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining work that are attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

1. Install anchor bolts, accurately located, to elevations required.
2. Install reglets to receive top edge of foundation sheet waterproofing and to receive through-wall flashing in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.
3. Install dovetail anchor slots in concrete structures as indicated.
4. Install FE/BR window and door embeds.
5. Install blast resistant window embeds.

3.3 REMOVING AND REUSING FORMS

A. General: Formwork, for sides of beams, walls, columns, and similar parts of the Work, that does not support weight of concrete may be removed after cumulatively curing at not less than 10 deg C for 24 hours after placing concrete provided concrete is hard enough to not be damaged by form-removal operations and provided curing and protection operations are maintained.

B. Leave formwork for beam soffits, joists, slabs, and other structural element, that supports weight of concrete in place until concrete has achieved the following:

1. At least 70 percent of 28-day design compressive strength, but not less than four days.
2. Determine compressive strength of in-place concrete by testing representative field- or laboratory-cured test specimens according to ACI 301.
3. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

C. 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-release agent.

D. When forms are reused, clean surfaces, remove fins and latience, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by COR.

3.4 SHORES AND RESHORES

A. Comply with ACI 318M, ACI 301, and recommendations in ACI 347R for design, installation, and removal of shoring and reshoring.

B. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.

C. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

3.5 VAPOR RETARDERS

A. Vapor Retarder: Place, protect, and repair vapor-retarder sheets according to ASTM E 1643 and manufacturer's written instructions.

1. Place vapor retarder sheeting in position with longest dimension parallel the direction of pour.
2. Lap joints: 150 mm and seal with manufacturer’s recommended mastic or pressure-sensitive tape.

3.6 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.

1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

B. Install in accordance with steel reinforcement placement shop drawings that have been reviewed by the Project Director.

C. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials.

D. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover as approved by the Project Director. Do not tack weld crossing reinforcing bars.

1. Shop- or field-weld reinforcement according to AWS D1.4, where indicated.
2. Welding of reinforcing bars is not permitted unless indicated on the structural drawings.

E. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

F. Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Secure overlaps with wire.

3.7 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by COR. Indicate locations and show details on shop drawing submittals.

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
2. Form from preformed galvanized steel, plastic keyway-section forms, or bulkhead forms with keys, unless otherwise indicated. Embed keys at least 40 mm into concrete.
3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
6. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

C. Contraction (Control) Joints in Slabs-on Grade: Construct contraction joints in slabs-on-grade to form panels of patterns as shown. Use saw cuts 3 mm wide by one-fourth of the slab depth or inserts 6 mm wide by one-fourth of slab depth, unless otherwise indicated.

1. Form contraction joints by inserting premolded plastic, hardboard, or fiberboard strip into fresh concrete until top surface of strip is flush with slab surface. Tool slab edges round on each side of insert. After concrete has cured, remove inserts and clean groove of loose debris.

2. Contraction joints in unexposed floor slabs may be formed by saw cuts as soon as possible after slab finishing as may be safely done without dislodging aggregate.
3. If joint pattern is not shown, provide joints not exceeding 4.5 meters in either direction and located to be conform to bay spacing wherever possible (at column centerlines, half bays, third bays).
4. Discontinue reinforcing through joint only as shown on the drawings.

D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.

1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.
2. Terminate full-width joint-filler strips not less than 12 mm or more than 25 mm below finished concrete surface where joint sealants, specified in Division 7 Section "Joint Sealants," are indicated.
3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

E. Dowel Joints: Install dowel sleeves and dowels or dowel bar and support assemblies at joints where indicated.

1. Use dowel sleeves or lubricate or asphalt-coat one-half of dowel length to prevent concrete bonding to one side of joint, unless indicated otherwise on the drawings.

3.8 WATERSTOPS

A. Flexible Waterstops: Install in construction joints as indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of Work. Field-fabricate joints in waterstops according to manufacturer's written instructions.

B. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's written instructions, bonding or mechanically fastening and firmly pressing into place. Install in longest lengths practicable.

3.9 CONCRETE PLACEMENT

A. General: Comply with ACI 304, “ Guide for Measuring, Mixing, Transporting, and Placing Concrete,” and as specified.

B. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

C. Do not add water to concrete during delivery, at Project site, or during placement, unless approved by Project Director.

D. Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as specified. Deposit concrete to avoid segregation and at such a rate of placement not to exceed the maximum shown on the formwork shop drawings.

E. Deposit concrete in forms in horizontal layers no deeper than 600 mm and in a manner to avoid inclined construction joints. Place each layer while preceding layer is still plastic, to avoid cold joints.

1. Consolidate placed concrete with mechanical vibrating equipment supplemented by hand spading, rodding, or tamping. Use equipment and procedures for consolidating concrete recommended by ACI 309R.
2. 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 vibrator. Place vibrators to rapidly penetrate placed layer and at least 150 mm into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. 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 constituents to segregate.

F. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
2. Maintain reinforcement in position on chairs during concrete placement.
3. Screed slab surfaces with a straightedge and strike off to correct elevations.
4. Slope surfaces uniformly to drains where required.
5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, free of humps or hollows, before excess moisture or bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

G. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When air temperature has fallen to or is expected to fall below 4 deg C, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 10 deg C and not more than 27 deg C at point of placement.
2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators, unless otherwise specified and approved in mix designs.

H. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows, when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 32 deg C at time of placement. Chilled mixing water 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.
2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.
4. Concrete placement shall not be started if the temperature is 40 deg. C and rising or until it is 43 deg. C and falling. All concrete placement shall be completed at ambient air temperature of less than 45 deg. C.

3.10 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defective areas repaired and patched. Remove fins and other projections exceeding ACI 347R limits for class of surface specified.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defective areas. Remove fins and other projections exceeding 3 mm in height.

1. Apply to concrete surfaces exposed to public view or to be covered with a coating or covering material applied directly to concrete, such as waterproofing, dampproofing, veneer plaster, or painting.

C. Rubbed Finish: Apply the following to smooth-formed finished concrete:

1. Smooth-Rubbed Finish: No later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white Portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.

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

3.11 FINISHING FLOORS AND SLABS

A. General: Comply with recommendations in ACI 302.1R for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces. Specified Overall Values (SOV) for flatness and Minimum Local Values (MLV) for both F_F (flatness) and F_L (levelness) are measured according to ASTM E 1155, Standard Test Method for Determining Floor Flatness and Levelness Using the F-Number System. F_L (levelness) shall be calculated for suspended slabs before slab shoring is removed.

B. Scratch Finish: While still plastic, texture concrete surface that has been screeded and bull-floated or darbied. to a tolerance of Specified Overall Value (SOV) F_F18 / F_L15 and Minimum Local Value (MLV) F_F13 / F_L10. Use stiff brushes, brooms, or rakes.

1. Apply scratch finish to surfaces indicated and to surfaces to receive concrete floor topping or mortar setting beds for ceramic or quarry tile, portland cement terrazzo, and other bonded cementitious floor finishes and where indicated.

2. Finish surface to a tolerance of Specified Overall Value (SOV) F_F18 / F_L15 and Minimum Local Value (MLV) F_F13 / F_L10.

C. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture. Grind smooth any surface defects that would telegraph through applied floor covering system.

1. Apply float finish to surfaces indicated on the Architectural Drawings, to surfaces to receive trowel finish, and to floor and slab surfaces to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo.

2. Finish surface to a tolerance of Specified Overall Value (SOV) F_F20 / F_L18 and Minimum Local Value (MLV) F_F15 / F_L12.

D. Trowel Finish: After applying float finish, apply first trowel finish and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.

1. Apply a trowel finish to surfaces indicated on Architectural Drawings and to floor and slab surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin film-finish coating system.

2. Finish surface to a tolerance of Specified Overall Value (SOV) F_F25 / F_L20 and Minimum Local Value (MLV) F_F17 / F_L15.

E. Trowel and Fine-Broom Finish: Apply a partial trowel finish, stopping after second troweling, to surfaces indicated on Architectural Drawings and to surfaces where ceramic or quarry tile is to be installed by either thickset or thin-set method. Immediately after second troweling, and when concrete is still plastic, slightly scarify surface with a fine broom.

F. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, and ramps, and elsewhere as indicated on Architectural Drawings.

1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with Project Director before application.

G. Slip-Resistive Aggregate Finish: Before final floating, apply slip-resistive aggregate finish where indicated on Architectural Drawings and to concrete stair treads, platforms, and ramps. Apply according to manufacturer's written instructions and as follows:

1. Uniformly spread 1.2 kg/m^2 (0.25 lbs/ft^2) of dampened slip-resistive aggregate over surface in one or two applications. Tamp aggregate flush with surface, but do not force below surface.
2. After broadcasting and tamping, apply float finish.
3. After curing, lightly work surface with a steel wire brush or an abrasive stone, and water to expose slip-resistive aggregate.

3.12 MISCELLANEOUS CONCRETE ITEMS

A. Filling In: Fill in holes and openings left in concrete structures, unless otherwise indicated, 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 indicated or required to complete Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

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

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

3.13 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with recommendations in ACI 305R for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 1 kg/m^2 x hour (0.20 lbs./ft.^{2} x hour) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing by one or a combination of the following methods:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 300-mm lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 300 mm, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

   a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
   b. Cure concrete surfaces to receive floor coverings by moisture cure or with either a moisture-retaining cover or a curing compound that the manufacturer recommends for use with floor coverings.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated on Architectural Drawings in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces, by one or a combination of the following methods:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 300-mm lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped

at least 300 mm, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

a. Moisture cure or use moisture-retaining covers to cure concrete.

3. Curing Compound: Apply curing compound to concrete slabs as soon as final finishing operations are complete (within 2 hours and after surface water sheen has disappeared. Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.
5. Hot-Weather Curing: Cure concrete according to recommendations in ACI 305R and as follows, when hot-weather conditions exist:

a. When ambient air temperature is expected to be greater or equal to 36 deg. C in the following seven days after flatwork is poured it shall be moist-cured for a minimum of seven days.

3.14 LIQUID FLOOR TREATMENTS

A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment according to manufacturer's written instructions.

1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
2. Do not apply to concrete that is less than 14 days old.
3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing. Rinse with water; remove excess material until surface is dry. Apply a second coat in a similar manner if surface is rough or porous. Comply with manufacturer’s written instructions.

B. Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete by power spray or roller according to manufacturer's written instructions.

3.15 JOINT FILLING

A. Prepare, clean, and install joint filler according to manufacturer's written instructions.

1. Defer joint filling until concrete has aged at least six months. Do not fill joints until construction traffic has permanently ceased.

B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.

C. Install semi-rigid epoxy joint filler the full depth in saw-cut joints and at least 50 mm deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.16 CONCRETE SURFACE REPAIRS

A. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removing forms, when acceptable to the Project Director. Remove and replace concrete that cannot be repaired and patched to the Project Directors approval.

B. Patching Mortar: Mix dry-pack mortar, consisting of one part Portland cement to 2½ parts fine aggregate passing a 1.2 mm (No. 16) sieve, using only enough water as required for handling and placing.

C. Repairing Formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of the Project Director. 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 discoloration that cannot be removed by cleaning.

1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 12 mm in any dimension in solid concrete but not less than 25 mm in depth. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cork cone plugs secured in place with bonding agent.
2. Repair defects on surfaces exposed to view by blending white Portland cement and standard Portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area 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.
3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by COR.

D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.25 mm wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
2. After concrete has cured at least 14 days, correct high areas by grinding.
3. Correct localized low areas 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 acceptable to the COR.

4. Correct other low areas scheduled to receive floor coverings with a repair underlayment when acceptable to the COR. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.
5. Correct other low areas scheduled to remain exposed with a repair topping when acceptable to the COR. Cut out low areas to ensure a minimum repair topping depth of 6 mm to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
6. Repair defective areas, except random cracks and single holes 25 mm or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least 20 mm clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mix as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
7. Repair random cracks and single holes 25 mm or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to COR approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to acceptance of the COR.

3.17 QUALITY CONTROL TESTING DURING CONSTRUCTION

A. General: The Contractor shall employ a qualified independent testing and inspecting agency, approved by the COR, to sample materials, perform tests, and submit test reports according to the requirements specified in this Article.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 50 m^3 or fraction thereof of each concrete mix placed each day unless directed otherwise by the Project Director. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mix, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
2. Slump: ASTM C 143; one test at point of discharge for each composite sample. Perform additional tests when concrete consistency appears to change.

3. Air Content: ASTM C 231; pressure method, for normal-weight concrete; ASTM C 173, volumetric method, for structural lightweight concrete; one test for each composite sample.
4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 4 deg C and below, when 27 deg C and above, and one test for each set of composite sample.
5. Unit Weight: ASTM C567; one test for each composite sample.
6. Compressive Test Specimens: ASTM C31/C31M; cast and laboratory cure one set of four standard cylinders specimens for each composite sample.
7. Compressive-Strength Tests: ASTM C39; one specimen tested at 7 days, two specimens tested at 28 days, and one specimen tested at 56 days (reserve).

C. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete as approved by the Project Director.

D. Test results shall be reported in writing to COR, ready-mix producer, and the Contractor within 24 hours after testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspection agency, 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, 28-day, and 56 day (reserve) tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by the COR but shall not be used as the sole basis for acceptance or rejection of concrete.

F. Additional Tests: The testing and inspecting agency shall make additional test 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 COR. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed by the COR. Any concrete that does not comply with this specification will not be accepted. Concrete found to be deficient shall be corrected in a manner satisfactory to the COR. All investigations, testing, load tests, and correction of deficiencies shall be performed at the expense of the Contractor and approved by the COR.

END OF SECTION 03300

I. CONCRETE MIX DESIGN SUBMITTAL FORM

Project: _____
City: _____
General Contractor: _____
Concrete Contractor: _____
Concrete Strength (Class): _____
Use (Describe): _____

Design Mix Information (Check One)

Based on Std. Deviation Analysis ☐
Trial Mix Text Data ☐

Design Characteristics

Density		kg/m^3
Strength		MPa (28 day)
Air		% specified

If trial mixes are used the Mix Design is proportioned to achieve f´cr = f´c + 8.3MPa
(9.7 MPa for 35MPa strength and higher strength at 28 days)

MATERIALS	Type/ Source	Specific Gravity	Weight (kg)	Absolute Volume (m^3)
Cement				
Fly Ash				
Silica Fume				
GGBF Slag				
Fine Aggregate				
Course Aggregate				
Water				
Air				
Other				
		Total		m^3

Water/Cementitious Material Ratio (kg water/kg cementitious material) = _____

ADMIXTURES	Manufacturer	Dosage (Metric)
Water Reducer		
Air Entraining Agent		
High Range Water Reducer		
Non-Corrosive Accelerator		

Other		

Slump before HRWR _____ mm
Slump after HRWR _____ mm

Standard Deviation Analysis (from experience records):

# of Test Cylinders Evaluated:	
Standard Deviation:	

The larger of: f'cr = f'c + 1.34s or f'cr = f'c + 2.33s-3.5 (MPa)

(Refer to ACI 301 for increased deviation factor when less than 30 tests are available. Refer to ACI 318M Section 5.3 – Proportioning on the basis of field experience or trial mixtures, or both.)

LABORATORY TESTS DATA

Compressive strength

Age (days)	Mix #1	Mix #2	Mix #3
7	MPa	MPa	MPa
7	MPa	MPa	MPa
28	MPa	MPa	MPa
28	MPa	MPa	MPa
28 average	MPa	MPa	MPa

REQUIRED ATTACHMENTS:

Combined Aggregate Gradation Report	
Standard Deviation Analysis Summary or Trial Mixture Test Data	
Admixture Compatibility Certification Letter	

Note: 8% - 18% aggregate required to be retained on each sieve except the top size and the #100

Submitted by :

Name: _____
Address: _____
_____
Phone #: _____
Main Plant Location: _____
Kilometers to Project: _____
Secondary Plant Location: _____
Kilometers to Project: _____

Date: _____