

SECTION 032000 - CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Reinforcing steel for cast-in-place concrete.
- B. Supports and accessories for steel reinforcement.

1.2 RELATED SECTIONS

- A. Section 033000 - Cast-in-Place Concrete.

1.3 REFERENCES

- A. ACI 301 - Specifications for Structural Concrete for Buildings; American Concrete Institute International.
- B. ACI 318 - Building Code Requirements for Reinforced Concrete and Commentary; American Concrete Institute International.
- C. ACI SP-66 - ACI Detailing Manual; American Concrete Institute International.
- D. ASTM A184/A184M - Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement.
- E. ASTM A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
- F. ASTM A704/A704M - Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement.
- G. ASTM A706/A706M - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
- H. ASTM A996/A996M - Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.
- I. ASTM A1064/A1064M - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed for Concrete.
- J. AWS D1.4 - Structural Welding Code - Reinforcing Steel; American Welding Society.
- K. CRSI (DA4) - Manual of Standard Practice; Concrete Reinforcing Steel Institute.
- L. CRSI (P1) - Placing Reinforcing Bars; Concrete Reinforcing Steel Institute.

1.4 SUBMITTALS

- A. Shop Drawings: Only when deviations are made from the contract documents, submit shop drawings under provision of Section 013000 with deviations clearly identified.
 - 1. Indicate sizes, spacings, locations and quantities of reinforcing steel, wire fabric, bending and cutting schedules, splicing, stirrup spacing, supporting and spacing devices.
- B. Manufacturer's Certificate: Certify that reinforcing steel and accessories supplied for this project meet or exceed specified requirements.
- C. Reports: Submit for file certified copies of mill test report of reinforcement materials analysis, indicate physical and chemical analysis.
- D. Welders Certificates: Submit for file certifications for welders employed on the project, verifying AWS qualifications with the previous 12 months.

1.5 QUALITY ASSURANCE

- A. Perform work of this section in accordance with CRSI (DA4), CRSI (P1), ACI 301, and ACI SP-66.

PART 2 - PRODUCTS

2.1 REINFORCEMENT

- A. Reinforcing Steel: ASTM A 615/A 615M Grade 60.
 - 1. Deformed billet-steel bars.
 - 2. Unfinished.
- B. Reinforcing Steel: ASTM A706/A706M, deformed low-alloy steel bars.
 - 1. Unfinished.
- C. Steel Welded Wire Reinforcement: ASTM A1064/A1064M, plain type.
 - 1. Welded Wire Mat Reinforcing: mesh size and gage as indicated on drawings.
- D. Steel Welded Wire Reinforcement: ASTM A1064/A1064M, deformed type.
 - 1. Flat Sheets.
 - 2. Mesh Size and Wire Gage: As indicated on drawings.
- E. Reinforcement Accessories:
 - 1. Tie Wire: Annealed, minimum 16 gage acceptable patented system.
 - 2. Provide stainless steel, plastic, or plastic coated steel components for placement within 1-½" of weathering surfaces.

2.2 FABRICATION

- A. Fabricate concrete reinforcing in accordance with CRSI (DA4) - Manual of Standard Practice.
- B. Welding of reinforcement is permitted only with the specific approval of Structural Engineer. Perform welding in accordance with AWS D1.4.
- C. Obtain approval from the architect for additional reinforcing splices not indicated on drawings.

PART 3 - EXECUTION

3.1 PLACEMENT

- A. Comply with requirements of ACI 301. Clean reinforcement of loose rust and mill scale, and accurately position, support, and secure in place to achieve not less than minimum concrete coverage required for protection.
- B. Install welded wire reinforcement in maximum possible lengths, and offset end laps in both directions. Splice laps with tie wire.
- C. Verify that anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not interfere with concrete placement.
- D. Do not displace or damage vapor barrier.
- E. Accommodate placement of formed openings.

3.2 FIELD QUALITY CONTROL

- A. An independent testing agency will inspect installed reinforcement for conformance to contract documents before concrete placement.

END OF SECTION 032000

SECTION 033000 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 WORK INCLUDES:

- A. Cast in place structural concrete.

1.2 RELATED SECTIONS:

- A. Section 032000 - Concrete Reinforcement.

1.3 REFERENCES

- A. ACI 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete; American Concrete Institute International.
- B. ACI 301 - Specifications for Structural Concrete for Buildings; American Concrete Institute International.
- C. ACI 302.1R - Guide for Concrete Floor and Slab Construction; American Concrete Institute International.
- D. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete; American Concrete Institute International.
- E. ACI 305R - Hot Weather Concreting; American Concrete Institute International.
- F. ACI 306R - Cold Weather Concreting; American Concrete Institute International.
- G. ACI 308R - Guide to Curing Concrete; American Concrete Institute International.
- H. ACI 318 - Building Code Requirements for Structural Concrete and Commentary; American Concrete Institute International.
- I. ASTM C33 - Standard Specification for Concrete Aggregates.
- J. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
- K. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.
- L. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic-Cement Concrete.
- M. ASTM C150 - Standard Specification for Portland cement.
- N. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete.

- O. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
- P. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
- Q. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
- R. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete.
- S. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
- T. ASTM C685/C685M – Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing.
- U. ASTM C881/C881M - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
- V. ASTM C1059 - Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete.
- W. ASTM C1107/C1107M - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
- X. ASTM E1155/E1155M - Standard Test Method for Determining F(F) Floor Flatness and F(L) Floor Levelness Numbers.

1.4 DEFINITIONS

- A. Severe Exposure: Concrete which is in contact with moisture or deicing salts, such as pavements, sidewalks, parking garage floors, etc.
- B. Moderate Exposure: Concrete which is occasionally exposed to moisture, such as exterior walls, beams, girders, and slabs not in contact with soil, etc.

1.5 SUBMITTALS

- A. General: Submit in accordance with Section 013300.
- B. Shop Drawings: Submit drawings locating slab-on-grade construction joints, control joints, and isolation joints.
- C. Mix Designs:
 - 1. Submit proposed concrete mix designs for each class or use at least 30 days prior to required delivery.
 - 2. Mixes shall be prepared by a professional engineer licensed in the State of Washington.
 - 3. Specifically indicate where each class of concrete is to be used.

4. Indicate individual and combined aggregate gradations and aggregate source and characteristics.

D. Test Reports: Submit aggregate and concrete mix test reports from independent testing laboratory as required by Division 1.

1.6 QUALITY ASSURANCE

A. Certifications:

1. Submit material certification for admixtures and aggregates, certifying their compliance with specifications.

2. Submit certified mill test reports for each lot of cement.

B. Perform work of this section in accordance with ACI 301 and ACI 318.

C. Acquire cement from same source and aggregate from same source for entire project.

D. Follow recommendations of ACI 305R for concreting during hot weather.

E. Follow recommendations of ACI 306R for concreting during cold weather

1.7 PRE-INSTALLATION CONFERENCE

A. Conduct pre-installation conference in accordance with Section 013100.

1.8 DELIVERY, STORAGE, AND HANDLING

A. General: Comply with requirements of Section 016000.

B. Deliver packaged products to site in manufacturer's sealed and labeled containers; inspect to verify compliance with specified requirements.

C. Label containers to indicate manufacturer's name, product name, date of manufacture, and instructions for use.

D. Store liquid materials in tightly covered containers in well ventilated area at ambient temperatures recommended by manufacturer. Store dry materials on raised platforms and cover to prevent moisture damage. Maintain containers in clean condition, free of foreign materials and residue with labels in legible condition.

E. Take precautionary measures to prevent fire hazards and spontaneous combustion.

PART 2 – PRODUCTS

2.1 REINFORCEMENT

A. Comply with the requirements of Section 032000.

2.2 CONCRETE MATERIALS

A. Portland Cement:

1. ASTM C150, Type as indicated in the structural drawings.
2. Air-entraining Portland cement, as defined by ASTM C150, is prohibited.

B. Aggregate:

1. Coarse Aggregate:
 - a. ASTM C33 for normal weight aggregate.
2. Fine Aggregate: ASTM C33.

C. Water: Clean, fresh and potable.

D. Admixtures:

1. Calcium chloride, thiocyanates, or admixtures containing more than 0.05 percent chloride ions are not permitted unless approved by Architect.
2. Air Entraining: ASTM C260.
3. Water-reducing: ASTM C494, Type A.
4. High Range Water-reducing (Superplasticizer): ASTM C494, Type F or Type G.
5. Water-reducing, Non-corrosive, Non-chloride Accelerator:
 - a. ASTM C494, Type E.
 - b. Submit long term non-corrosive test data from independent testing laboratory using accelerated test method such as electrical potential measure.
6. Water-reducing, Retarding: ASTM C494, Type D.

2.3 CURING MATERIALS

- A. Wet Cure: Building slabs shall be wet cured (saturated wet coverings with water) and covered in conformance with NFS Guide to Concrete Subfloor and Floor Covering Practices Section 2.2. No spray or troweled on curing compounds to be used. Place wet blankets after concrete has hardened enough to prevent surface damage. Wet blankets shall be kept constantly wet.

2.4 PATCHING AND REPAIR MATERIALS

A. Epoxy Adhesive:

1. 100 percent solids, two component material suitable for use on dry or damp surfaces, conforming to ASTM C881.
2. Acceptable Products and Manufacturers:
 - a. Concsive Liquid LPL, Master Builders, Inc., Cleveland, OH.

- b. Sikadur Hi-Mod 32, Sika Corporation, Lyndhurst, NJ.
- c. Euco 452 or 620 System, Euclid Chemical Company, Cleveland, OH.

B. Patching Compound:

- 1. Polymer modified cementitious mortar.
- 2. Acceptable Products and Manufacturers:
 - a. Thin Coat, Concrete Coat, or Verticoat, Euclid Chemical Company, Cleveland, OH.
 - b. Duratop, L&M Construction Chemicals, Inc., Omaha, NE.
 - c. Sikatop 121, 122, or 123, Sika Corporation, Lyndhurst, NJ.

C. Patching Mortar:

- 1. Comprised of same materials and approximately same proportions as used for surrounding concrete, except with coarse aggregate omitted.
- 2. Consisting of not more than 1 part cement to 2-1/2 parts sand.
- 3. Substitute white Portland cement for portion of gray Portland cement to match color of surrounding exposed concrete.
- 4. Limit mixing water to no more than necessary for handling and placing. Maximum water/cement ratio of 0.50.

D. Bonding Agent:

- 1. Acrylic, ASTM C1059, Type II, Non redispersable.
- 2. Acceptable Products and Manufacturers:
 - a. Everbond, L&M Construction Chemicals, Inc., Omaha, NE.
 - b. Daraweld-C, Grace Construction Products, Cambridge, MA.
 - c. Intralok, W. R. Meadows, Inc., Elgin IL.

E. Evaporation Retardants:

- 1. Eucofilm, Euclid Chemical Co., Cleveland, OH.
- 2. E-Con, L&M Construction Chemicals, Inc., Omaha, NE.
- 3. Confilm, Master Builders, Inc., Cleveland, OH.

2.5 RELATED MATERIALS:

- A. Vapor Barrier: Polyethylene sheet, ASTM D4397, not less than 15 mils thick; or plastic sheeting, ASTM E1745, Class C.

2.6 CONCRETE MIXES

A. Mix Design:

1. Submit design mixes for each type and class of concrete based on laboratory trial batch method or field experience methods described in ACI-318, Chapter 5.
 2. If trial batch method is used, employ an independent testing agency acceptable to Architect for preparing and reporting proposed mix designs. Mix designs are to be prepared by a professional engineer licensed in the State of Washington. Contractor employed testing agency shall not be same firm as Owner employed testing agency.
 3. Use concrete of approved mix designs only.
 4. The proportioning of ingredients shall provide a concrete readily worked into forms and around reinforcement under conditions of placement to be employed, without segregation or excessive bleeding.
 5. Do not place concrete until design mix for that class and type of concrete is reviewed by Architect.
 6. Indicate locations in structure where each mix design is to be used.
 7. Identify each mix design with code number which will be used on batch tickets.
- B. Design Compressive Strengths: As indicated on Structural Drawings.
1. Normal Weight Concrete:
 - a. Compressive strength, when tested in accordance with ASTM C39/C39M, strength at 7 days shall be at least 60% of the minimum required 28 day strength unless noted otherwise on drawings.
 - b. Maximum slump 4 inches \pm 1", UNO.
- C. Maximum Size of Coarse Aggregate:
1. 1/5 narrowest dimension between form sides.
 2. 1/3 depth of slabs.
 3. 3/4 of minimum clear distance between reinforcing bars, wires, or bundles of bars.
 4. 1 inch maximum for normal weight concrete
- D. Concrete Slump at Point of Discharge:
1. Ramps and Sloping Surfaces: Not more than 3 inches.
 2. Reinforced Foundations: Not less than 1 inch and not more than 4 inches.
 3. Concrete Containing Superplasticizer: Not more than 9 inches after addition of superplasticizer. Slump before addition of superplasticizer: 2 to 3 inches
 4. Other Concrete: Not less than 1 inch and not more than 4 inches, UNO.
 5. Allowable tolerances of up to 1 inch above maximum indicated provided average of 10 most recent batches tested is less than maximum.

- E. Minimum Cement Content: Not less than 470 pounds of total cementitious material per cubic yard of concrete. Not more than 25% flyash or pozzolan cement substitute and not less than 385 pounds of cement per cubic yard of concrete.
- F. Water-Cement Ratios for Concrete (by weight):
1. The maximum permissible water cement ratio shall be as follows:
 - a. Normal-weight concrete slabs: 0.40
- G. Admixtures:
1. Only use admixtures which have been tested and approved in mix designs.
- H. Shrinkage Tests:
1. Prior to placing any concrete for walls or horizontal surfaces, a trial batch of each mix design of structural concrete shall be prepared using the aggregates, cement and admixture (if any) proposed for the project. From each trial batch at least 3 specimens for determining drying shrinkage shall be prepared. The drying shrinkage specimens shall be a 4" x 4" x 11" prisms fabricated, cured, dried, and measured in accordance with the requirements of Tentative Method of Test for Length Change of Cement Mortar and Concrete, ASTM C157. The measurements shall be made and reported separately for 7 and 28 days of drying after 7 days of moist curing. The effective gage length of the specimens shall be 10", and except for the foundation concrete, the average drying shrinkage at 35 days shall not exceed .054%.
 2. Previous Test: Ready-mixed concrete manufacturer may furnish certified test reports from approved Testing Laboratory as proof of meeting shrinkage requirements, provided aggregate used and concrete covered by such test report conform to mix design approved for use on this project. Method used, use an independent testing facility acceptable to Architect for preparing and reporting proposed mix designs.
- I. Use accelerating admixtures in cold weather only when approved by architect. Use of admixtures will not relax cold weather placement requirements.

2.7 MIXING

- A. Ready-Mix Concrete:
1. Comply with ASTM C94/C94M.
 2. Before using trucks for batching, mixing, and transporting concrete, thoroughly clean trucks and equipment of materials capable of contaminating concrete.
 3. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C94 is required.
 4. When air temperature is between 85 degrees F and 90 degrees F, reduce mixing and delivery time from 90 minutes to 75 minutes, and when air temperature is above 90 degrees F, reduce mixing and delivery time to 60 minutes.

5. Do not add water to ready-mix concrete at Project site except when slump is below specified limits and total water does not exceed the design water-cement ratio; inject added water into mixer and mix thoroughly before discharging.
- B. Provide certificate signed by authorized official of supplier with each load of concrete stating following:
1. Time truck left plant.
 2. Mix of concrete, identify with code number of mix design.
 3. Amount of water and cement in mix.
 4. Amount and type of admixtures.
 5. Amount of water added at project site.
 6. Time truck is unloaded at project site.
- C. Truck mixers without batch tickets will be rejected.
- D. Retain certificates at Project site. Submit to Architect for review upon request.

2.8 PRODUCTION

A. Ready Mixed Concrete

1. Except as otherwise provided in these specifications, ready mixed concrete shall be batched, mixed, and transported in accordance with ASTM C94 "Specification for Ready Mixed Concrete."

B. Mixing Water Control

1. Concrete which arrives at the jobsite with slump below that specified for placement may be adjusted by the addition of water to increase slump, provided the maximum slump is not exceeded and the maximum water content of the design mix is not exceeded. Following any such water addition, the concrete shall be mixed at mixing speed for at least 30 revolutions of the drum.
2. After adjustment is made to the proper slump, the concrete shall be discharged as long as it retains its placeability without the further addition of water.
3. Concrete shall be placed within one and one half hours after mixer is charged in average conditions. Time shall be reduced to one hour during hot weather concreting.

2.9 SOURCE QUALITY CONTROL

- A. Testing will be performed under the provisions of Section 01 4500, except as otherwise specified.

- B. Independent Testing Laboratory, approved by Architect and employed by Contractor, is responsible for:
1. Testing aggregate as follows at start of work and whenever change in aggregate source occurs:
 - a. Gradation and fineness modulus: ASTM C136.
 - b. Specific gravity: ASTM C127 for coarse aggregate, ASTM C128 for fine aggregate.
 - c. Organic impurities: ASTM C40.
 - d. Effect of organic impurities on strength: ASTM C87 for effect of organic impurities on strength.
 - e. Potential reactivity of aggregate: ASTM C295, petrographic examination.
 - f. Soundness: ASTM C88.
 - g. Reports of tests conducted on aggregates from the same source within the past 12 months will be acceptable.
 2. Testing concrete mixes as follows at start of work and whenever change in materials source occurs:
 - a. Prepare mix designs, test concrete strength, and report results if trial batch method is used to establish design mix proportions. Mix design shall be reviewed, approved, sealed and stamped by a Licensed Professional Engineer in the state where the project is located.
- C. Independent Testing Laboratory, employed by Owner, is responsible for observing and evaluating the following at batch plant at start of Work and at other times as requested by the Architect:
1. Condition of batching equipment.
 2. Conformance with design mix proportions.
 3. Storage of materials.
 4. Mixing equipment.
 5. Mixing and transporting equipment.
 6. Other testing to verify compliance if requested by Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions and proceed with Work in accordance with Section 01 7300.
- B. Verify forms, reinforcement, anchors, plates, joint materials, vapor retarder and other items to be cast into concrete are accurately placed and held securely.
- C. Verify forms are free of debris and water.

- D. Verify excavations are free of loose material and water.

3.2 TESTING

- A. Concrete materials and operations shall be tested and inspected for compliance with the specifications and requirements.

3.3 TESTING AGENCY

- A. The testing agency shall be designated by the owner. Ample time shall be allowed for preliminary tests as required prior to concreting operations.
- B. All testing agency personnel shall meet the requirements of ASTM E329, "Recommended Practice of Inspecting and Testing Agencies for Concrete and Steel in Construction."
- C. All testing agency personnel shall have the knowledge and ability to perform the necessary tests equivalent to the minimum guideline for Certification of Concrete Field Testing Technicians, Grade 1 in accordance with ACI CP-2.

3.4 DUTIES AND SERVICES

- A. The duties and responsibilities of the testing agency and the contractor and services to be performed by each are as designated in ACI 301, Chapter 16, "Specifications for Structural Concrete for Buildings."

3.5 EVALUATION AND ACCEPTANCE

- A. Test results of standard cylinders, molded, cured, and tested according to ASTM C31 and C39 should be evaluated separately for each concrete mix according to ACI 214, "Recommended Practice for Evaluation of Concrete Compression Test Results of Field Concrete."
- B. The criteria for acceptance of concrete shall be as detailed in ACI 318, Chapter 5, Section 5.6, "Evaluation and Acceptance of Concrete" or as per ASTM C94, Section 17 "Strength" and Section 18 "Failure to Meet Strength Requirements."
- C. As referenced in ASTM C94 – Section 4.4, "When the strength of concrete is used as a basis for acceptance, the manufacturer shall be entitled to copies of all test reports."

3.6 PREPARATION

- A. Construction Joints:
 - 1. Clean previously placed concrete of laitance.
 - 2. Clean reinforcement and accessories of mortar from previous concrete placement operations.
 - 3. Apply bonding agent in accordance with manufacturer's recommendations.

4. Moisten surface of previously placed concrete.

3.7 PLACEMENT

- A. Place concrete according to ACI 301 and 304R, except as modified and supplemented on Drawings or in this Section.
- B. Notify Architect and Owner's testing laboratory minimum of 48 hours prior to commencement of placing operations.
- C. Cold Weather Concreting:
 1. Comply with requirements of ACI 306.1.
 2. Do not place concrete when ambient air temperature is expected to fall below 40 degrees F within 24 hours, except with prior written approval of Architect.
 3. Remove frost, ice, and snow from formwork, reinforcing, and accessories prior to placing concrete.
 4. Do not place concrete foundations, footings or slabs on frozen ground.
 5. Limit concrete temperature at time of discharge to 55 degrees F for sections less than 12 inches in any dimension and to 50 degrees F for other sections.
- D. Hot Weather Concreting:
 1. Comply with requirements of ACI 305R when ambient air temperature exceeds 75 degrees F.
 2. Use water-reducing, retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions to extend setting time to limits specified as approved by Architect.
 3. Cool aggregates, cool mixing water, substitute ice for part of mixing water, or take other measures to limit concrete temperature at time of discharge to 90 degrees F.
 4. Cover reinforcing steel and steel forms with water soaked burlap or use fog spray to limit temperature of steel to 120 degrees F immediately prior to concrete placement.
 5. Use evaporation retardant between finishing passes.
- E. At time of placement, provide concrete temperature between 50 degrees F and 90 degrees F.
- F. Ensure reinforcement, inserts, waterstops, embedded parts, and formed construction joint devices will not be disturbed during concrete placement.
- G. Repair underslab vapor retarder damaged during placement of concrete reinforcing. Repair with vapor retarder material; lap over damaged areas minimum 6 inches and seal watertight.
- H. Separate slabs on grade from vertical surfaces with joint filler.

- I. Place joint filler in floor slab pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.
- J. Extend joint filler from bottom of slab to within 1/2 inch of finished slab surface. Conform to Section 07900 for finish joint sealer requirements.
- K. Install joint devices in accordance with manufacturer's instructions.
- L. Install construction joint devices in coordination with floor slab pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.
- M. Install joint device anchors for expansion joint assemblies. Maintain correct position to allow joint cover to be flush with floor and wall finish.
- N. Apply sealants in joint devices in accordance with manufacturer specifications.
- O. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.
- P. Place concrete continuously between predetermined expansion, control, and construction joints.
- Q. Do not interrupt successive placement; do not permit cold joints to occur.
- R. Place floor slabs in pattern indicated.
- S. Saw cut joints within 12 hours after placing.
- T. Screed floors level, maintaining surface flatness of maximum 1/4 inch in 10 ft.
- U. Screed floors level, maintaining the minimum F(F) Floor Flatness and F(L) Floor Levelness values specified when measured in accordance with ASTM E1155/ASTM E1155M.
- V. Maintain surfaces receiving concrete at approximately same temperature as concrete being placed.
- W. Maintain surface of hardened concrete below 100 degrees F.
- X. Convey concrete from mixer to place of deposit by method that will prevent segregation or loss of material, and that will not require addition of water to produce desired slump at point of placement. Do not use supported reinforcing as runway base for concrete conveying equipment.
- Y. Depositing:
 - 1. Deposit concrete as nearly as practicable to its final location.
 - 2. Place concrete continuously between construction joints.
 - 3. Deposit concrete in layers not exceeding 24 inches in depth.
 - 4. Avoid inclined layers.

5. Place each layer while preceding layer is still plastic.
6. Do not allow free fall of concrete to exceed 4 feet (ConXtech HSS Columns excluded). Do not allow free fall of concrete containing high-range water reducing admixture to exceed 10 feet.
7. Drop concrete in vertical direction, not at incline.
8. Place beams, girders, haunches, brackets, column capitals, and drop panels monolithic with slab system unless otherwise indicated.
9. Do not cast beams, girders, and slabs supported on columns and walls until concrete in supporting element is no longer plastic, minimum of 2 hours.
10. If forms and reinforcing above level of concrete already in place become coated with accumulations of hardened or partially hardened concrete, remove accumulations before proceeding.
11. Place concrete without displacing reinforcing and accessories.

Z. Consolidation:

1. Vibrate concrete to eliminate formation of surface air voids, honeycombs and sand streaks.
2. Use mechanical, internal vibrators with proper frequency, rpm, and spud size. Select spud for size and spacing of reinforcement and clearance to formwork. Supplement vibration by hand-spading, rodding, or tamping.
3. Insert and withdraw vibrator vertically at spacing not to exceed 1-1/2 times radius of action of vibrator, maximum of 24 inch centers.
4. Insert vibrators into placed layer and at least 6 inches into preceding layer.
5. Do not allow vibrator to touch form face or embedded items.
6. Do not use mechanical vibration for slabs less than 4 inches thick. Use hand spading and tamping in these locations.

AA. Placing Concrete Slabs:

1. Deposit and consolidate concrete slabs in continuous operation, in single layer, within limits of construction joints, until placing of panel or section is completed.
2. Bring slab surfaces to correct level with straightedge and strike-off.
3. Use bull floats, highway straight edges, or darbies to produce smooth surface, free of humps or hollows before bleed water appears on surface.
4. Do not disturb slab surfaces prior to beginning finishing operations.

BB. Non-Structural Concrete Topping:

1. Placement on same day:
 - a. Place and consolidate base slab.
 - b. Screed to elevation to allow for topping slab thickness.
 - c. After bleed water has disappeared and surface will support worker's weight without indentation, place topping mixture, compact, float and finish.
2. Placement after one day:
 - a. Place and consolidate base slab.
 - b. Brush partially set surface with wire broom to remove laitance and scratch surface.
 - c. Wet cure base slab at least three days.
 - d. Immediately, prior to placing topping, clean base slab and dampen surface.
 - e. Scrub bonding grout into base slab surface [, or apply bonding agent in accordance with manufacturer's recommendations].
 - f. Rewettable bonding agent may be used only in areas not subject to wet conditions.
 - g. Place topping slab before grout has set or dried, compact, float and finish.

CC. Curbs and Equipment Pads:

1. Form curbs and equipment pads in areas indicated.
2. Placement on same day:
 - a. Place and consolidate base slab.
 - b. Screed to elevation to allow for curb/pad thickness.
 - c. After bleed water has disappeared and surface will support worker's weight without indentation, place curb/pad concrete mixture, compact, and float.
3. Placement after one day:
 - a. Place and consolidate base slab.
 - b. Brush partially set surface with wire broom to remove laitance and scratch surface.
 - c. Wet cure base slab at least three days.
 - d. Immediately, prior to placing curb/pad concrete, clean base slab and dampen surface.
 - e. Scrub bonding grout into base slab surface, or apply bonding agent in accordance with manufacturer's recommendations.
 - f. Place curb/pad concrete before grout has set or dried, compact and float.
4. Finish interior curbs and pads by stripping forms while concrete is still green and steel trowel surfaces to hard, dense finish with corners, intersections and terminations slightly rounded.

3.8 DEPOSITING

- A. Concrete shall be continuously deposited. When continuous placement is not possible, construction joints shall be located as approved by the Architect. Concrete shall be deposited as close to its final point of placement as possible.
- B. Concrete shall be consolidated by vibration, spading, rodding or forking. Work concrete around reinforcements, embedded items and into corners. Eliminate all air or rock pockets and other causes of honeycombing, pitting or planes of weakness.

- C. Internal vibration shall have a minimum frequency with amplitude to consolidate the concrete effectively. See ACI 309, "Recommended Practice for Consolidation of Concrete."
1. Vibrators shall be operated by experienced and competent workmen.
 2. Use of vibrators to transport concrete shall not be allowed.
 3. Vibrators shall be vertically inserted every 18 inches for 5 to 15 seconds and then withdrawn.

3.9 CURING

A. General:

1. Comply with ACI-308, except as modified or supplemented.
2. Start immediately after placing and finishing concrete once concrete is hard enough to prevent surface damage.
3. Protect from premature drying, temperature extremes, temperature variations, rain, flowing water, and mechanical injury.
4. Cure continuously, without allowing to dry, for minimum period required for hydration of cement and hardening of concrete. Wet cure only using wet saturated blankets continuously kept wet for full duration of cure.
5. Maintain temperature of concrete above 50 degrees F for curing period.
6. Minimum Length of Curing Period:
 - a. Per ACI Committee 301
 - b. Concrete must reach minimum 70% of design strength (28-day $f'c$)
 - c. Minimum of seven days (type I cement), ten days (type II cement), fourteen days (type IV or V cement).

3.10 FIELD QUALITY CONTROL

A. Field testing will be performed under the provisions of Section 01 4500.

B. Independent testing laboratory, employed by Owner, is responsible for:

1. Sampling Fresh Concrete: ASTM C172, sample at point of discharge from mixer and additionally at point of discharge from end of pipe for concrete conveyed by pumping methods; if water is added at Project site, obtain another sample for testing.
2. Concrete Temperature: Test each time slump and air content are tested and each time set of compressive strength test specimens is made.
3. Slump: ASTM C143; one test from first truck at point of discharge each day, one test each time set of compressive strength test specimens is made, and when change in consistency occurs.

4. Compressive Strength Tests:
 - a. Make and cure test specimens in accordance with ASTM C31, from concrete sampled at point of discharge from mixer and additionally at point of discharge from end of pipe for concrete conveyed by pumping methods.
 - b. Make one set of 4 test cylinder specimens for every 100 cubic yards, or for every 5000 square feet of slabs and walls, or fraction thereof, of each class of concrete, with at least one set for each class each day.
 - c. Test cylinders in accordance with ASTM C39, 2 at 7 days for information, and 2 at 28 days for acceptance.
 - d. When frequency of testing will provide less than five strength tests for a given class of concrete, conduct testing from at least 5 randomly selected batches, or from each batch if fewer than 5 are used.
 5. Environmental Conditions:
 - a. When ambient air temperature falls below 40 degrees F, record maximum and minimum air temperature in each 24 hour period; record air temperature inside protective enclosure; record minimum temperature of surface of hardened concrete.
 - b. When ambient air temperature rises above 85 degrees F, record maximum and minimum air temperature in each 24 hour period; record minimum relative humidity; record maximum wind velocity, and record maximum temperature of surface of hardened concrete.
 6. Observe conveying, placement and consolidation of concrete for conformance to Specifications.
 7. Observe condition of formed surfaces upon removal of formwork prior to repair of surface defects and observe repair of surface defects.
 8. Observe curing procedures for conformance with Specifications, record dates of concrete placement, start of preliminary curing, start of final curing, end of curing period.
 9. Observe Preparations for Placement of Concrete:
 - a. Inspect handling, conveying, and placing equipment, inspect vibrating and compacting equipment.
 - b. Inspect preparation of construction, expansion, and isolation joints.
 10. Observe preparations for protection from hot weather, cold weather, sun, and rain and preparations for curing.
 11. Observations of Concrete Mixing:
 - a. Monitor and record amount of water added at Project site.
 - b. Observe minimum and maximum mixing times.
 12. Other Inspections:
 - a. Grouting under base plates.
 - b. Grouting anchor bolts and reinforcing steel in hardened concrete.
- C. Evaluation and Acceptance of Concrete:

1. Strength Test: Defined as average strength of two 28 day cylinder tests from each set of cylinders.
2. Acceptance Criteria Based on Strength Tests: Strength level of individual class of concrete is considered satisfactory if both:
 - a. Average of three consecutive strength test results equal or exceed required design compressive strength, and
 - b. No individual strength test results falls below required design compressive strength by more than 500 psi.
3. Acceptance Criteria Based on Field Tests:
 - a. Core Tests: Where strength tests indicate concrete of deficient strength, obtain and test cores in accordance with ASTM C42, ACI 318 and ACI-301, at locations directed by Architect.
 - b. Strength level of concrete in area represented by core test is considered adequate if complies with the requirements of ACI 318.
 - c. Fill core holes with low slump concrete or patching mortar used to repair surface defects.
4. Revise concrete mix proportions, curing procedures and protection as necessary to provide concrete conforming to Specifications.

D. Acceptance of Structure:

1. Acceptance of structure for dimensional tolerances, appearance, and strength will be based on ACI-301, Chapter 18.
2. Remove and replace concrete which does not meet acceptance criteria.

3.11 PATCHING AND REPAIRING DEFECTIVE CONCRETE

A. General:

1. Rewettable bonding agent may be used only in areas not subject to wet conditions.
2. Patching compound may only be used for concrete not exposed to view.

B. Repairing Formed Surfaces:

1. Surface Defects Requiring Repair:
 - a. Color and texture irregularities.
 - b. Honeycomb, air bubbles, rock pockets, and spalls.
 - c. Fins, burrs and other surface projections.
 - d. Cracks.
 - e. Stains and other discolorations that cannot be removed by cleaning.
2. Patch defective areas and tie holes immediately after removal of forms.
3. Cut out honeycomb, rock pockets, and voids over 1/4 inch down to solid concrete but not less than 1 inch depth.

4. Make edges of cuts perpendicular to concrete surface.
5. Clean and dampen area including 6 inches of surrounding surface with water.
6. Apply bonding grout by brushing into surface, after surface water has evaporated.
7. Place patching mortar or patching compound before grout has set or dried.
8. Compact patching material in place and strike off slightly higher than surrounding surface.
9. Finish after minimum of one hour to match surrounding surface.
10. Flush out form tie holes, fill with patching mortar, patching compound, or precast cement cone plugs secured in place with bonding compound.
11. Cure repair areas by same methods as surrounding concrete or keep continuously damp for 7 days.

C. Repairing Unformed Surfaces:

1. Surface Defects Requiring Repair:
 - a. Fine crazing cracks.
 - b. Cracks larger than 0.012 inch wide or cracks which penetrate to reinforcing.
 - c. Cracks penetrating completely through non-reinforced sections.
 - d. Spalling, popouts, honeycomb, and rock pockets.
 - e. High and low areas in slabs.
2. Correct high areas in hardened concrete by grinding after concrete has cured at least 14 days.
3. Correct high and low areas during, or immediately after, completion of initial floating operations by cutting high areas and by placing fresh concrete in low areas.
4. Repair defective areas, except isolated random cracks and single holes not exceeding 1 inch diameter, by cutting out and replacing with patching mortar or patching compound.
 - a. Remove defective areas to sound concrete with clean, square cuts.
 - b. Dampen concrete surfaces in contact with patching material and apply bonding grout by brushing into surface, after surface water has disappeared.
 - c. Place patching mortar or patching compound before grout has set or dried.
 - d. Compact and finish to blend with adjacent finished concrete.
 - e. Cure in same manner as adjacent concrete.
5. Repair isolated random cracks and single holes not over 1 inch diameter with patching mortar.
 - a. Groove top of cracks and cut out holes to sound concrete and clean area.
 - b. Dampen cleaned surfaces and apply bonding grout by brushing into surface, after surface water has disappeared.
 - c. Place patching material before bonding grout is set or dry.
 - d. Compact in place and finish to match adjacent concrete.
 - e. Keep patched area continuously moist for not less than 72 hours.

- D. Structural Repairs: Contractor shall proposed materials, methods, and procedures to the Architect for review and approval prior to proceed with structural repairs.

3.12 PROTECTION

- A. Protect finished work in accordance with Division 1.
- B. Protect concrete from construction traffic, weather, or mechanical damage for 14 days after placing.
- C. Provide raised runways for traffic areas.
- D. Protect concrete from staining.

END OF SECTION 033000

SECTION 033053 - MISCELLANEOUS CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes miscellaneous cast-in-place concrete, including reinforcement, concrete materials, mixture design, placement procedures, and finishes. This is for all concrete not covered by Sections in related requirements, for example, fence posts, on grade equipment pads etc.
- B. Related Requirements:
 - 1. Section 312000 "Earth Moving" for drainage fill under slabs-on-grade.
 - 2. Section 321313 "Concrete Paving" for concrete pavement and walks.
 - 3. Section 033000 "Cast In Place Concrete" for structural concrete, slabs-on-grade and elevated deck concrete fill.
 - 4. Section 032000 "Concrete Reinforcement" for steel reinforcing of concrete.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Design Mixtures: For each concrete mixture.

1.4 QUALITY ASSURANCE

- A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. Comply with the following sections of **ACI 301 (ACI 301M)** unless modified by requirements in the Contract Documents:
 - 1. "General Requirements."

2. "Formwork and Formwork Accessories."
3. "Reinforcement and Reinforcement Supports."
4. "Concrete Mixtures."
5. "Handling, Placing, and Constructing."
6. "Lightweight Concrete."

B. Comply with **ACI 117 (ACI 117M)**.

2.2 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, **Grade 60 (Grade 420)**, deformed.

2.3 CONCRETE MATERIALS

A. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

B. Cementitious Materials:

1. Portland Cement: ASTM C 150/C 150M, Type II.
2. Fly Ash: ASTM C 618, Class C or F.
3. Slag Cement: ASTM C 989/C 989M, Grade 100 or 120.
4. Blended Hydraulic Cement: ASTM C 595/C 595M, Type IP, portland-pozzolan cement.

C. Normal-Weight Aggregate: ASTM C 33/C 33M, 1" nominal maximum aggregate size.

D. Air-Entraining Admixture: ASTM C 260/C 260M.

E. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

F. Water: ASTM C 94/C 94M.

2.4 RELATED MATERIALS

A. Vapor Retarder: Polyethylene sheet, ASTM D 4397, not less than **15 mils** thick; or plastic sheet, ASTM E 1745, Class C.

B. Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork.

2.5 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.
- B. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth or cotton mats.
- C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- D. Water: Potable.
- E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.
- F. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

2.6 CONCRETE MIXTURES

- A. Comply with **ACI 301 (ACI 301M)**.
- B. Normal-Weight Concrete:
 - 1. Minimum Compressive Strength: **4000 psi (27.6 MPa)** at 28 days, uno on plans
 - 2. Maximum W/C Ratio: 0.40, uno on plans
 - 3. Cementitious Materials: Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not more than 25 percent.
 - 4. Slump Limit: **4 inches (100 mm)**, plus or minus **1 inch (25 mm)**.
 - 5. Air Content: Maintain within range permitted by **ACI 301 (ACI 301M)**. Do not allow air content of trowel-finished floor slabs to exceed 3 percent.

2.7 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and ASTM C 1116/C 1116, and furnish batch ticket information.
 - 1. When air temperature is above **90 deg F (32 deg C)**, reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 - 1. For mixer capacity of **1 cu. yd. (0.76 cu. m)** or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 - 2. For mixer capacity larger than **1 cu. yd. (0.76 cu. m)**, increase mixing time by 15 seconds for each additional **1 cu. yd. (0.76 cu. m)**.
 - 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mix type, mix time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 FORMWORK INSTALLATION

- A. Design, construct, erect, brace, and maintain formwork according to **ACI 301 (ACI 301M)**.

3.2 EMBEDDED ITEM INSTALLATION

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

3.3 VAPOR-RETARDER INSTALLATION

- A. Install, protect, and repair vapor retarders according to ASTM E 1643; place sheets in position with longest dimension parallel with direction of pour.
 - 1. Lap joints **6 inches (150 mm)** and seal with manufacturer's recommended adhesive or joint tape.

3.4 STEEL REINFORCEMENT INSTALLATION

- A. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
 - 1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

3.5 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 Architect.
- C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness, as follows:
 - 1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut **1/8-inch- (3.2-mm-)** wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

- 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.

3.6 CONCRETE PLACEMENT

- A. Comply with **ACI 301 (ACI 301M)** for placing concrete.
- B. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of **ACI 301 (ACI 301M)**.
- C. Do not add water to concrete during delivery, at Project site, or during placement.
- D. Consolidate concrete with mechanical vibrating equipment according to **ACI 301 (ACI 301M)**.
- E. Equipment Bases and Foundations:
1. Coordinate sizes and locations of concrete bases with actual equipment provided.
 2. Construct concrete bases **4 inches (100 mm)** high unless otherwise indicated; and extend base not less than **6 inches (150 mm)** in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated or unless required for seismic anchor support.
 3. Minimum Compressive Strength: **4000 psi (27.6 MPa)** at 28 days, uno on plans.
 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor them into structural concrete substrate.
 6. Prior to pouring concrete, place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 7. Cast anchor-bolt insert into bases. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.7 FINISHING FORMED SURFACES

- A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections exceeding **1/2 inch (13 mm)**.
1. Apply to concrete surfaces not exposed to public view.
- 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 **1/8 inch (3 mm)**.

1. Apply to concrete surfaces exposed to public view, or to be covered with a coating or covering material applied directly to concrete.
- C. Rubbed Finish: Apply the following rubbed finish, defined in **ACI 301 (ACI 301M)**, to smooth-formed-finished as-cast concrete where indicated:
1. Smooth-rubbed finish.
 2. Grout-cleaned finish.
 3. Cork-floated finish.
- 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.

3.8 FINISHING UNFORMED SURFACES

- A. General: Comply with ACI 302.1R for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Screed surfaces with a straightedge and strike off. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane before excess moisture or bleedwater appears on surface.
1. Do not further disturb surfaces before starting finishing operations.
- C. Scratch Finish: Apply scratch finish to surfaces indicated and surfaces to receive concrete floor topping or mortar setting beds for ceramic or quarry tile, portland cement terrazzo, and other bonded cementitious floor finishes unless otherwise indicated.
- D. Float Finish: Apply float finish to surfaces indicated, to surfaces to receive trowel finish, and to floor and slab surfaces to be covered with fluid-applied or sheet waterproofing, fluid-applied or direct-to-deck-applied membrane roofing, or sand-bed terrazzo.
- E. Trowel Finish: Apply a hard trowel finish to surfaces indicated 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.
- F. Trowel and Fine-Broom Finish: Apply a partial trowel finish, stopping after second troweling, to surfaces indicated and to surfaces where ceramic or quarry tile is to be installed by either thickset or thinset methods. Immediately after second troweling, and when concrete is still plastic, slightly scarify surface with a fine broom.
- G. Slip-Resistive Broom Finish: Apply a slip-resistive finish to surfaces indicated and to exterior concrete platforms, steps, and ramps. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.

3.9 CONCRETE PROTECTING 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 **ACI 301 (ACI 301M)** for hot-weather protection during curing.
- B. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching **0.2 lb/sq. ft. x h (1 kg/sq. m x h)** 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. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- D. Curing Methods: Cure formed and unformed concrete for at least seven days 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 **12-inch (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 **12 inches (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.
 - 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 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.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Tests: Perform according to **ACI 301 (ACI 301M)**.
 - 1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding **5 cu. yd. (4 cu. m)**, but less than **25 cu. yd. (19 cu. m)**, plus one set for each additional **50 cu. yd. (38 cu. m)** or fraction thereof.

2. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. (76 cu. m) or fraction thereof of each concrete mixture placed each day.

END OF SECTION 033053

SECTION 032000 - CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Reinforcing steel for cast-in-place concrete.
- B. Supports and accessories for steel reinforcement.

1.2 RELATED SECTIONS

- A. Section 033000 - Cast-in-Place Concrete.

1.3 REFERENCES

- A. ACI 301 - Specifications for Structural Concrete for Buildings; American Concrete Institute International.
- B. ACI 318 - Building Code Requirements for Reinforced Concrete and Commentary; American Concrete Institute International.
- C. ACI SP-66 - ACI Detailing Manual; American Concrete Institute International.
- D. ASTM A184/A184M - Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement.
- E. ASTM A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
- F. ASTM A704/A704M - Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement.
- G. ASTM A706/A706M - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
- H. ASTM A996/A996M - Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.
- I. ASTM A1064/A1064M - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed for Concrete.
- J. AWS D1.4 - Structural Welding Code - Reinforcing Steel; American Welding Society.
- K. CRSI (DA4) - Manual of Standard Practice; Concrete Reinforcing Steel Institute.
- L. CRSI (P1) - Placing Reinforcing Bars; Concrete Reinforcing Steel Institute.

1.4 SUBMITTALS

- A. Shop Drawings: Only when deviations are made from the contract documents, submit shop drawings under provision of Section 013000 with deviations clearly identified.
 - 1. Indicate sizes, spacings, locations and quantities of reinforcing steel, wire fabric, bending and cutting schedules, splicing, stirrup spacing, supporting and spacing devices.
- B. Manufacturer's Certificate: Certify that reinforcing steel and accessories supplied for this project meet or exceed specified requirements.
- C. Reports: Submit for file certified copies of mill test report of reinforcement materials analysis, indicate physical and chemical analysis.
- D. Welders Certificates: Submit for file certifications for welders employed on the project, verifying AWS qualifications with the previous 12 months.

1.5 QUALITY ASSURANCE

- A. Perform work of this section in accordance with CRSI (DA4), CRSI (P1), ACI 301, and ACI SP-66.

PART 2 - PRODUCTS

2.1 REINFORCEMENT

- A. Reinforcing Steel: ASTM A 615/A 615M Grade 60.
 - 1. Deformed billet-steel bars.
 - 2. Unfinished.
- B. Reinforcing Steel: ASTM A706/A706M, deformed low-alloy steel bars.
 - 1. Unfinished.
- C. Steel Welded Wire Reinforcement: ASTM A1064/A1064M, plain type.
 - 1. Welded Wire Mat Reinforcing: mesh size and gage as indicated on drawings.
- D. Steel Welded Wire Reinforcement: ASTM A1064/A1064M, deformed type.
 - 1. Flat Sheets.
 - 2. Mesh Size and Wire Gage: As indicated on drawings.
- E. Reinforcement Accessories:
 - 1. Tie Wire: Annealed, minimum 16 gage acceptable patented system.
 - 2. Provide stainless steel, plastic, or plastic coated steel components for placement within 1-½" of weathering surfaces.

2.2 FABRICATION

- A. Fabricate concrete reinforcing in accordance with CRSI (DA4) - Manual of Standard Practice.
- B. Welding of reinforcement is permitted only with the specific approval of Structural Engineer. Perform welding in accordance with AWS D1.4.
- C. Obtain approval from the architect for additional reinforcing splices not indicated on drawings.

PART 3 - EXECUTION

3.1 PLACEMENT

- A. Comply with requirements of ACI 301. Clean reinforcement of loose rust and mill scale, and accurately position, support, and secure in place to achieve not less than minimum concrete coverage required for protection.
- B. Install welded wire reinforcement in maximum possible lengths, and offset end laps in both directions. Splice laps with tie wire.
- C. Verify that anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not interfere with concrete placement.
- D. Do not displace or damage vapor barrier.
- E. Accommodate placement of formed openings.

3.2 FIELD QUALITY CONTROL

- A. An independent testing agency will inspect installed reinforcement for conformance to contract documents before concrete placement.

END OF SECTION 032000

SECTION 033000 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 WORK INCLUDES:

- A. Cast in place structural concrete.

1.2 RELATED SECTIONS:

- A. Section 032000 - Concrete Reinforcement.

1.3 REFERENCES

- A. ACI 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete; American Concrete Institute International.
- B. ACI 301 - Specifications for Structural Concrete for Buildings; American Concrete Institute International.
- C. ACI 302.1R - Guide for Concrete Floor and Slab Construction; American Concrete Institute International.
- D. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete; American Concrete Institute International.
- E. ACI 305R - Hot Weather Concreting; American Concrete Institute International.
- F. ACI 306R - Cold Weather Concreting; American Concrete Institute International.
- G. ACI 308R - Guide to Curing Concrete; American Concrete Institute International.
- H. ACI 318 - Building Code Requirements for Structural Concrete and Commentary; American Concrete Institute International.
- I. ASTM C33 - Standard Specification for Concrete Aggregates.
- J. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
- K. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.
- L. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic-Cement Concrete.
- M. ASTM C150 - Standard Specification for Portland cement.
- N. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete.

- O. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
- P. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
- Q. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
- R. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete.
- S. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
- T. ASTM C685/C685M – Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing.
- U. ASTM C881/C881M - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
- V. ASTM C1059 - Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete.
- W. ASTM C1107/C1107M - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
- X. ASTM E1155/E1155M - Standard Test Method for Determining F(F) Floor Flatness and F(L) Floor Levelness Numbers.
- Y. CPAA –Concrete Polishing Association of America- Recommendations for the Design, Specification and Placement of Concrete Floor Slabs.

1.4 DEFINITIONS

- A. Severe Exposure: Concrete which is in contact with moisture or deicing salts, such as pavements, sidewalks, parking garage floors, etc.
- B. Moderate Exposure: Concrete which is occasionally exposed to moisture, such as exterior walls, beams, girders, and slabs not in contact with soil, etc.

1.5 SUBMITTALS

- A. General: Submit in accordance with Section 013300.
- B. Shop Drawings: Submit drawings locating slab-on-grade construction joints, control joints, and isolation joints.
- C. Mix Designs:
 - 1. Submit proposed concrete mix designs for each class or use at least 30 days prior to required delivery.

2. Mixes shall be prepared by a professional engineer licensed in the State of Washington.
3. Specifically indicate where each class of concrete is to be used.
4. Indicate individual and combined aggregate gradations and aggregate source and characteristics.
5. Test Reports: Submit aggregate and concrete mix test reports from independent testing laboratory as required by Division 1.
6. For the portion of the concrete that may be polished (floor slabs and elevated deck fill), each mix ingredient should be from the same source, from the same respective batch, and each delivered to the concrete producer in one delivery.
 - a. Use Type 1 portland cement per ASTM C150 unless otherwise noted.
 - b. Use water cement ratio of .45.
 - c. Use minimum of not less than 3 uniformly graded aggregate sizes- fine , intermediate and large.
 - d. Air entrainment is not allowed.
 - e. Inclusions of admixtures, plasticizers, slag, fly ash or other products replacing Portland cement in the mix is not allowed.
 - f. Minimum compressive strength is 4000 psi.

1.6 QUALITY ASSURANCE

A. Certifications:

1. Submit material certification for admixtures and aggregates, certifying their compliance with specifications.
2. Submit certified mill test reports for each lot of cement.

B. Perform work of this section in accordance with ACI 301 and ACI 318.

C. Acquire cement from same source and aggregate from same source for entire project.

D. Follow recommendations of ACI 305R for concreting during hot weather.

E. Follow recommendations of ACI 306R for concreting during cold weather

1.7 PRE-INSTALLATION CONFERENCE

A. Conduct pre-installation conference in accordance with Section 013100.

1.8 DELIVERY, STORAGE, AND HANDLING

A. General: Comply with requirements of Section 016000.

B. Deliver packaged products to site in manufacturer's sealed and labeled containers; inspect to verify compliance with specified requirements.

- C. Label containers to indicate manufacturer's name, product name, date of manufacture, and instructions for use.
- D. Store liquid materials in tightly covered containers in well ventilated area at ambient temperatures recommended by manufacturer. Store dry materials on raised platforms and cover to prevent moisture damage. Maintain containers in clean condition, free of foreign materials and residue with labels in legible condition.
- E. Take precautionary measures to prevent fire hazards and spontaneous combustion.

PART 2 – PRODUCTS

2.1 REINFORCEMENT

- A. Comply with the requirements of Section 032000.

2.2 CONCRETE MATERIALS

A. Portland Cement:

- 1. ASTM C150, Type as indicated in the structural drawings.
- 2. Air-entraining Portland cement, as defined by ASTM C150, is prohibited.

B. Aggregate:

- 1. Coarse Aggregate:
 - a. ASTM C33 for normal weight aggregate.
- 2. Fine Aggregate: ASTM C33.

C. Water: Clean, fresh and potable.

D. Admixtures:

- 1. Calcium chloride, thiocyanates, or admixtures containing more than 0.05 percent chloride ions are not permitted unless approved by Architect.
- 2. Air Entraining: Not allowed.
- 3. Water-reducing: ASTM C494, Type A.
- 4. High Range Water-reducing (Superplasticizer): ASTM C494, Type F or Type G.
- 5. Water-reducing, Non-corrosive, Non-chloride Accelerator:
 - a. ASTM C494, Type E.
 - b. Submit long term non-corrosive test data from independent testing laboratory using accelerated test method such as electrical potential measure.
- 6. Water-reducing, Retarding: ASTM C494, Type D.

2.3 CURING MATERIALS

- A. Wet Cure: Building slabs shall be wet cured (saturated wet coverings with water) and covered in conformance with NFS Guide to Concrete Subfloor and Floor Covering Practices Section 2.2. No spray or troweled on curing compounds to be used. Place wet blankets after concrete has hardened enough to prevent surface damage. Wet blankets shall be kept constantly wet.

2.4 PATCHING AND REPAIR MATERIALS

A. Epoxy Adhesive:

1. 100 percent solids, two component material suitable for use on dry or damp surfaces, conforming to ASTM C881.
2. Acceptable Products and Manufacturers:
 - a. Concreative Liquid LPL, Master Builders, Inc., Cleveland, OH.
 - b. Sikadur Hi-Mod 32, Sika Corporation, Lyndhurst, NJ.
 - c. Euco 452 or 620 System, Euclid Chemical Company, Cleveland, OH.

B. Patching Compound:

1. Polymer modified cementitious mortar.
2. Acceptable Products and Manufacturers:
 - a. Thin Coat, Concrete Coat, or Verticoat, Euclid Chemical Company, Cleveland, OH.
 - b. Duratop, L&M Construction Chemicals, Inc., Omaha, NE.
 - c. Sikatop 121, 122, or 123, Sika Corporation, Lyndhurst, NJ.

C. Patching Mortar:

1. Comprised of same materials and approximately same proportions as used for surrounding concrete, except with coarse aggregate omitted.
2. Consisting of not more than 1 part cement to 2-1/2 parts sand.
3. Substitute white Portland cement for portion of gray Portland cement to match color of surrounding exposed concrete.
4. Limit mixing water to no more than necessary for handling and placing. Maximum water/cement ratio of 0.50.

D. Bonding Agent:

1. Acrylic, ASTM C1059, Type II, Non redispersable.
2. Acceptable Products and Manufacturers:
 - a. Everbond, L&M Construction Chemicals, Inc., Omaha, NE.
 - b. Daraweld-C, Grace Construction Products, Cambridge, MA.
 - c. Intralok, W. R. Meadows, Inc., Elgin IL.

E. Evaporation Retardants:

1. Eucofilm, Euclid Chemical Co., Cleveland, OH.
2. E-Con, L&M Construction Chemicals, Inc., Omaha, NE.
3. Confilm, Master Builders, Inc., Cleveland, OH.

2.5 RELATED MATERIALS:

- A. Vapor Barrier: Polyethylene sheet, ASTM D4397, not less than 15 mils thick; or plastic sheeting, ASTM E1745, Class C.

2.6 CONCRETE MIXES

A. Mix Design:

1. Submit design mixes for each type and class of concrete based on laboratory trial batch method or field experience methods described in ACI-318, Chapter 5.
2. If trial batch method is used, employ an independent testing agency acceptable to Architect for preparing and reporting proposed mix designs. Mix designs are to be prepared by a professional engineer licensed in the State of Washington. Contractor employed testing agency shall not be same firm as Owner employed testing agency.
3. Use concrete of approved mix designs only.
4. The proportioning of ingredients shall provide a concrete readily worked into forms and around reinforcement under conditions of placement to be employed, without segregation or excessive bleeding.
5. Do not place concrete until design mix for that class and type of concrete is reviewed by Architect.
6. Indicate locations in structure where each mix design is to be used.
7. Identify each mix design with code number which will be used on batch tickets.

B. Design Compressive Strengths: As indicated on Structural Drawings.

1. Normal Weight Concrete:
 - a. Compressive strength, when tested in accordance with ASTM C39/C39M, strength at 7 days shall be at least 60% of the minimum required 28 day strength unless noted otherwise on drawings.
 - b. Maximum slump 4 inches \pm 1", UNO.

C. Maximum Size of Coarse Aggregate:

1. 1/5 narrowest dimension between form sides.
2. 1/3 depth of slabs.

3. 3/4 of minimum clear distance between reinforcing bars, wires, or bundles of bars.
 4. 1 inch maximum for normal weight concrete
- D. Concrete Slump at Point of Discharge:
1. Ramps and Sloping Surfaces: Not more than 3 inches.
 2. Reinforced Foundations: Not less than 1 inch and not more than 4 inches.
 3. Concrete Containing Superplasticizer: Not more than 9 inches after addition of superplasticizer. Slump before addition of superplasticizer: 2 to 3 inches
 4. Other Concrete: Not less than 1 inch and not more than 4 inches, UNO.
 5. Allowable tolerances of up to 1 inch above maximum indicated provided average of 10 most recent batches tested is less than maximum.
- E. Minimum Cement Content: Not less than 470 pounds of total cementitious material per cubic yard of concrete. Not more than 25% flyash or pozzolan cement substitute and not less than 385 pounds of cement per cubic yard of concrete.
- F. Water-Cement Ratios for Concrete (by weight):
1. The maximum permissible water cement ratio shall be as follows:
 - a. Normal-weight concrete slabs: 0.40
- G. Admixtures:
1. Only use admixtures which have been tested and approved in mix designs.
- H. Shrinkage Tests:
1. Prior to placing any concrete for walls or horizontal surfaces, a trial batch of each mix design of structural concrete shall be prepared using the aggregates, cement and admixture (if any) proposed for the project. From each trial batch at least 3 specimens for determining drying shrinkage shall be prepared. The drying shrinkage specimens shall be a 4" x 4" x 11" prisms fabricated, cured, dried, and measured in accordance with the requirements of Tentative Method of Test for Length Change of Cement Mortar and Concrete, ASTM C157. The measurements shall be made and reported separately for 7 and 28 days of drying after 7 days of moist curing. The effective gage length of the specimens shall be 10", and except for the foundation concrete, the average drying shrinkage at 35 days shall not exceed .054%.
 2. Previous Test: Ready-mixed concrete manufacturer may furnish certified test reports from approved Testing Laboratory as proof of meeting shrinkage requirements, provided aggregate used and concrete covered by such test report conform to mix design approved for use on this project. Method used, use an independent testing facility acceptable to Architect for preparing and reporting proposed mix designs.
- I. Use accelerating admixtures in cold weather only when approved by architect. Use of admixtures will not relax cold weather placement requirements.

2.7 MIXING

A. Ready-Mix Concrete:

1. Comply with ASTM C94/C94M.
2. Before using trucks for batching, mixing, and transporting concrete, thoroughly clean trucks and equipment of materials capable of contaminating concrete.
3. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C94 is required.
4. When air temperature is between 85 degrees F and 90 degrees F, reduce mixing and delivery time from 90 minutes to 75 minutes, and when air temperature is above 90 degrees F, reduce mixing and delivery time to 60 minutes.
5. Do not add water to ready-mix concrete at Project site except when slump is below specified limits and total water does not exceed the design water-cement ratio; inject added water into mixer and mix thoroughly before discharging.

B. Provide certificate signed by authorized official of supplier with each load of concrete stating following:

1. Time truck left plant.
2. Mix of concrete, identify with code number of mix design.
3. Amount of water and cement in mix.
4. Amount and type of admixtures.
5. Amount of water added at project site.
6. Time truck is unloaded at project site.

C. Truck mixers without batch tickets will be rejected.

D. Retain certificates at Project site. Submit to Architect for review upon request.

2.8 PRODUCTION

A. Ready Mixed Concrete

1. Except as otherwise provided in these specifications, ready mixed concrete shall be batched, mixed, and transported in accordance with ASTM C94 "Specification for Ready Mixed Concrete."

B. Mixing Water Control

1. Concrete which arrives at the jobsite with slump below that specified for placement may be adjusted by the addition of water to increase slump, provided the maximum slump is not exceeded and the maximum water content of the design mix is not exceeded. Following any such water addition, the concrete shall be mixed at mixing speed for at least 30 revolutions of the drum.
2. After adjustment is made to the proper slump, the concrete shall be discharged as long as it retains its placeability without the further addition of water.
3. Concrete shall be placed within one and one half hours after mixer is charged in average conditions. Time shall be reduced to one hour during hot weather concreting.

2.9 SOURCE QUALITY CONTROL

- A. Testing will be performed under the provisions of Section 01 4500, except as otherwise specified.
- B. Independent Testing Laboratory, approved by Architect and employed by Contractor, is responsible for:
 1. Testing aggregate as follows at start of work and whenever change in aggregate source occurs:
 - a. Gradation and fineness modulus: ASTM C136.
 - b. Specific gravity: ASTM C127 for coarse aggregate, ASTM C128 for fine aggregate.
 - c. Organic impurities: ASTM C40.
 - d. Effect of organic impurities on strength: ASTM C87 for effect of organic impurities on strength.
 - e. Potential reactivity of aggregate: ASTM C295, petrographic examination.
 - f. Soundness: ASTM C88.
 - g. Reports of tests conducted on aggregates from the same source within the past 12 months will be acceptable.
 2. Testing concrete mixes as follows at start of work and whenever change in materials source occurs:
 - a. Prepare mix designs, test concrete strength, and report results if trial batch method is used to establish design mix proportions. Mix design shall be reviewed, approved, sealed and stamped by a Licensed Professional Engineer in the state where the project is located.
- C. Independent Testing Laboratory, employed by Owner, is responsible for observing and evaluating the following at batch plant at start of Work and at other times as requested by the Architect:
 1. Condition of batching equipment.
 2. Conformance with design mix proportions.
 3. Storage of materials.
 4. Mixing equipment.

5. Mixing and transporting equipment.
6. Other testing to verify compliance if requested by Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions and proceed with Work in accordance with Section 01 7300.
- B. Verify forms, reinforcement, anchors, plates, joint materials, vapor retarder and other items to be cast into concrete are accurately placed and held securely.
- C. Verify forms are free of debris and water.
- D. Verify excavations are free of loose material and water.

3.2 TESTING

- A. Concrete materials and operations shall be tested and inspected for compliance with the specifications and requirements.

3.3 TESTING AGENCY

- A. The testing agency shall be designated by the owner. Ample time shall be allowed for preliminary tests as required prior to concreting operations.
- B. All testing agency personnel shall meet the requirements of ASTM E329, "Recommended Practice of Inspecting and Testing Agencies for Concrete and Steel in Construction."
- C. All testing agency personnel shall have the knowledge and ability to perform the necessary tests equivalent to the minimum guideline for Certification of Concrete Field Testing Technicians, Grade 1 in accordance with ACI CP-2.

3.4 DUTIES AND SERVICES

- A. The duties and responsibilities of the testing agency and the contractor and services to be performed by each are as designated in ACI 301, Chapter 16, "Specifications for Structural Concrete for Buildings."
- B. For concrete that is subject to polishing follow the CPAA Concrete Polishing Association of America recommendations for the design, specification and placement of concrete floor slabs.

3.5 EVALUATION AND ACCEPTANCE

- A. Test results of standard cylinders, molded, cured, and tested according to ASTM C31 and C39 should be evaluated separately for each concrete mix according to ACI 214, "Recommended Practice for Evaluation of Concrete Compression Test Results of Field Concrete."

- B. The criteria for acceptance of concrete shall be as detailed in ACI 318, Chapter 5, Section 5.6, "Evaluation and Acceptance of Concrete" or as per ASTM C94, Section 17 "Strength" and Section 18 "Failure to Meet Strength Requirements."
- C. As referenced in ASTM C94 – Section 4.4, "When the strength of concrete is used as a basis for acceptance, the manufacturer shall be entitled to copies of all test reports."

3.6 PREPARATION

- A. Construction Joints:
 - 1. Clean previously placed concrete of laitance.
 - 2. Clean reinforcement and accessories of mortar from previous concrete placement operations.
 - 3. Apply bonding agent in accordance with manufacturer's recommendations.
 - 4. Moisten surface of previously placed concrete.

3.7 PLACEMENT

- A. Place concrete according to ACI 301 and 304R, except as modified and supplemented on Drawings or in this Section.
- B. Notify Architect and Owner's testing laboratory minimum of 48 hours prior to commencement of placing operations.
- C. Cold Weather Concreting:
 - 1. Comply with requirements of ACI 306.1.
 - 2. Do not place concrete when ambient air temperature is expected to fall below 40 degrees F within 24 hours, except with prior written approval of Architect.
 - 3. Remove frost, ice, and snow from formwork, reinforcing, and accessories prior to placing concrete.
 - 4. Do not place concrete foundations, footings or slabs on frozen ground.
 - 5. Limit concrete temperature at time of discharge to 55 degrees F for sections less than 12 inches in any dimension and to 50 degrees F for other sections.
- D. Hot Weather Concreting:
 - 1. Comply with requirements of ACI 305R when ambient air temperature exceeds 75 degrees F.
 - 2. Use water-reducing, retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions to extend setting time to limits specified as approved by Architect.

3. Cool aggregates, cool mixing water, substitute ice for part of mixing water, or take other measures to limit concrete temperature at time of discharge to 90 degrees F.
 4. Cover reinforcing steel and steel forms with water soaked burlap or use fog spray to limit temperature of steel to 120 degrees F immediately prior to concrete placement.
 5. Use evaporation retardant between finishing passes.
- E. At time of placement, provide concrete temperature between 50 degrees F and 90 degrees F.
 - F. Ensure reinforcement, inserts, waterstops, embedded parts, and formed construction joint devices will not be disturbed during concrete placement.
 - G. Repair underslab vapor retarder damaged during placement of concrete reinforcing. Repair with vapor retarder material; lap over damaged areas minimum 6 inches and seal watertight.
 - H. Separate slabs on grade from vertical surfaces with joint filler.
 - I. Place joint filler in floor slab pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.
 - J. Extend joint filler from bottom of slab to within 1/2 inch of finished slab surface. Conform to Section 07900 for finish joint sealer requirements.
 - K. Install joint devices in accordance with manufacturer's instructions.
 - L. Install construction joint devices in coordination with floor slab pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.
 - M. Install joint device anchors for expansion joint assemblies. Maintain correct position to allow joint cover to be flush with floor and wall finish.
 - N. Apply sealants in joint devices in accordance with manufacturer specifications.
 - O. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.
 - P. Place concrete continuously between predetermined expansion, control, and construction joints.
 - Q. Do not interrupt successive placement; do not permit cold joints to occur.
 - R. Place floor slabs in pattern indicated.
 - S. Saw cut joints within 12 hours after placing. Use a saw blade that has a triangular arbor configuration to reduce edge raveling or dislodging aggregates.
 - T. Screed floors level, maintaining minimum local values of F(F) Floor Flatness of 35 and F(L) Floor Levelness value of 20 and Specified Overall Values of F(F) Floor Flatness of 50 and F(L) Floor Levelness value of 30 when measured in accordance with ASTM E1155/ASTM E1155M.

- U. Maintain surfaces receiving concrete at approximately same temperature as concrete being placed.
- V. Maintain surface of hardened concrete below 100 degrees F.
- W. Convey concrete from mixer to place of deposit by method that will prevent segregation or loss of material, and that will not require addition of water to produce desired slump at point of placement. Do not use supported reinforcing as runway base for concrete conveying equipment.
- X. Depositing:
 - 1. Deposit concrete as nearly as practicable to its final location.
 - 2. Place concrete continuously between construction joints.
 - 3. Deposit concrete in layers not exceeding 24 inches in depth.
 - 4. Avoid inclined layers.
 - 5. Place each layer while preceding layer is still plastic.
 - 6. Do not allow free fall of concrete to exceed 4 feet (ConXtech HSS Columns excluded). Do not allow free fall of concrete containing high-range water reducing admixture to exceed 10 feet.
 - 7. Drop concrete in vertical direction, not at incline.
 - 8. Place beams, girders, haunches, brackets, column capitals, and drop panels monolithic with slab system unless otherwise indicated.
 - 9. Do not cast beams, girders, and slabs supported on columns and walls until concrete in supporting element is no longer plastic, minimum of 2 hours.
 - 10. If forms and reinforcing above level of concrete already in place become coated with accumulations of hardened or partially hardened concrete, remove accumulations before proceeding.
 - 11. Place concrete without displacing reinforcing and accessories.
- Y. Consolidation:
 - 1. Vibrate concrete to eliminate formation of surface air voids, honeycombs and sand streaks.
 - 2. Use mechanical, internal vibrators with proper frequency, rpm, and spud size. Select spud for size and spacing of reinforcement and clearance to formwork. Supplement vibration by hand-spading, rodding, or tamping.
 - 3. Insert and withdraw vibrator vertically at spacing not to exceed 1-1/2 times radius of action of vibrator, maximum of 24 inch centers.

4. Insert vibrators into placed layer and at least 6 inches into preceding layer.
5. Do not allow vibrator to touch form face or embedded items.
6. Do not use mechanical vibration for slabs less than 4 inches thick. Use hand spading and tamping in these locations.

Z. Placing Concrete Slabs:

1. Deposit and consolidate concrete slabs in continuous operation, in single layer, within limits of construction joints, until placing of panel or section is completed.
2. Bring slab surfaces to correct level with straightedge and strike-off.
3. Use bull floats, highway straight edges, or darbies to produce smooth surface, free of humps or hollows before bleed water appears on surface.
4. Do not disturb slab surfaces prior to beginning finishing operations.

AA. Non-Structural Concrete Topping:

1. Placement on same day:
 - a. Place and consolidate base slab.
 - b. Screed to elevation to allow for topping slab thickness.
 - c. After bleed water has disappeared and surface will support worker's weight without indentation, place topping mixture, compact, float and finish.
2. Placement after one day:
 - a. Place and consolidate base slab.
 - b. Brush partially set surface with wire broom to remove laitance and scratch surface.
 - c. Wet cure base slab at least three days.
 - d. Immediately, prior to placing topping, clean base slab and dampen surface.
 - e. Scrub bonding grout into base slab surface [, or apply bonding agent in accordance with manufacturer's recommendations].
 - f. Rewettable bonding agent may be used only in areas not subject to wet conditions.
 - g. Place topping slab before grout has set or dried, compact, float and finish.

BB. Curbs and Equipment Pads:

1. Form curbs and equipment pads in areas indicated.
2. Placement on same day:
 - a. Place and consolidate base slab.
 - b. Screed to elevation to allow for curb/pad thickness.
 - c. After bleed water has disappeared and surface will support worker's weight without indentation, place curb/pad concrete mixture, compact, and float.
3. Placement after one day:
 - a. Place and consolidate base slab.
 - b. Brush partially set surface with wire broom to remove laitance and scratch surface.
 - c. Wet cure base slab at least three days.

- d. Immediately, prior to placing curb/pad concrete, clean base slab and dampen surface.
 - e. Scrub bonding grout into base slab surface, or apply bonding agent in accordance with manufacturer's recommendations.
 - f. Place curb/pad concrete before grout has set or dried, compact and float.
4. Finish interior curbs and pads by stripping forms while concrete is still green and steel trowel surfaces to hard, dense finish with corners, intersections and terminations slightly rounded.

3.8 DEPOSITING

- A. Concrete shall be continuously deposited. When continuous placement is not possible, construction joints shall be located as approved by the Architect. Concrete shall be deposited as close to its final point of placement as possible.
- B. Concrete shall be consolidated by vibration, spading, rodding or forking. Work concrete around reinforcements, embedded items and into corners. Eliminate all air or rock pockets and other causes of honeycombing, pitting or planes of weakness.
- C. Internal vibration shall have a minimum frequency with amplitude to consolidate the concrete effectively. See ACI 309, "Recommended Practice for Consolidation of Concrete."
 1. Vibrators shall be operated by experienced and competent workmen.
 2. Use of vibrators to transport concrete shall not be allowed.
 3. Vibrators shall be vertically inserted every 18 inches for 5 to 15 seconds and then withdrawn.

3.9 CURING

- A. General:
 1. Comply with ACI-308, except as modified or supplemented.
 2. Start immediately after placing and finishing concrete once concrete is hard enough to prevent surface damage.
 3. Protect from premature drying, temperature extremes, temperature variations, rain, flowing water, and mechanical injury.
 4. Cure continuously, without allowing to dry, for minimum period required for hydration of cement and hardening of concrete. Wet cure only using wet saturated blankets continuously kept wet for full duration of cure.
 5. Maintain temperature of concrete above 50 degrees F for curing period.
 6. Minimum Length of Curing Period:
 - a. Per ACI Committee 301
 - b. Concrete must reach minimum 70% of design strength (28-day f'c)

- c. Minimum of seven days (type I cement), ten days (type II cement), fourteen days (type IV or V cement).

3.10 FIELD QUALITY CONTROL

- A. Field testing will be performed under the provisions of Section 01 4500.
- B. Independent testing laboratory, employed by Owner, is responsible for:
 1. Sampling Fresh Concrete: ASTM C172, sample at point of discharge from mixer and additionally at point of discharge from end of pipe for concrete conveyed by pumping methods; if water is added at Project site, obtain another sample for testing.
 2. Concrete Temperature: Test each time slump and air content are tested and each time set of compressive strength test specimens is made.
 3. Slump: ASTM C143; one test from first truck at point of discharge each day, one test each time set of compressive strength test specimens is made, and when change in consistency occurs.
 4. Compressive Strength Tests:
 - a. Make and cure test specimens in accordance with ASTM C31, from concrete sampled at point of discharge from mixer and additionally at point of discharge from end of pipe for concrete conveyed by pumping methods.
 - b. Make one set of 4 test cylinder specimens for every 100 cubic yards, or for every 5000 square feet of slabs and walls, or fraction thereof, of each class of concrete, with at least one set for each class each day.
 - c. Test cylinders in accordance with ASTM C39, 2 at 7 days for information, and 2 at 28 days for acceptance.
 - d. When frequency of testing will provide less than five strength tests for a given class of concrete, conduct testing from at least 5 randomly selected batches, or from each batch if fewer than 5 are used.
 5. Environmental Conditions:
 - a. When ambient air temperature falls below 40 degrees F, record maximum and minimum air temperature in each 24 hour period; record air temperature inside protective enclosure; record minimum temperature of surface of hardened concrete.
 - b. When ambient air temperature rises above 85 degrees F, record maximum and minimum air temperature in each 24 hour period; record minimum relative humidity; record maximum wind velocity, and record maximum temperature of surface of hardened concrete.
 6. Observe conveying, placement and consolidation of concrete for conformance to Specifications.
 7. Observe condition of formed surfaces upon removal of formwork prior to repair of surface defects and observe repair of surface defects.
 8. Observe curing procedures for conformance with Specifications, record dates of concrete placement, start of preliminary curing, start of final curing, end of curing period.

9. Observe Preparations for Placement of Concrete:
 - a. Inspect handling, conveying, and placing equipment, inspect vibrating and compacting equipment.
 - b. Inspect preparation of construction, expansion, and isolation joints.
10. Observe preparations for protection from hot weather, cold weather, sun, and rain and preparations for curing.
11. Observations of Concrete Mixing:
 - a. Monitor and record amount of water added at Project site.
 - b. Observe minimum and maximum mixing times.
12. Other Inspections:
 - a. Grouting under base plates.
 - b. Grouting anchor bolts and reinforcing steel in hardened concrete.

C. Evaluation and Acceptance of Concrete:

1. Strength Test: Defined as average strength of two 28 day cylinder tests from each set of cylinders.
2. Acceptance Criteria Based on Strength Tests: Strength level of individual class of concrete is considered satisfactory if both:
 - a. Average of three consecutive strength test results equal or exceed required design compressive strength, and
 - b. No individual strength test results falls below required design compressive strength by more than 500 psi.
3. Acceptance Criteria Based on Field Tests:
 - a. Core Tests: Where strength tests indicate concrete of deficient strength, obtain and test cores in accordance with ASTM C42, ACI 318 and ACI-301, at locations directed by Architect.
 - b. Strength level of concrete in area represented by core test is considered adequate if complies with the requirements of ACI 318.
 - c. Fill core holes with low slump concrete or patching mortar used to repair surface defects.
4. Revise concrete mix proportions, curing procedures and protection as necessary to provide concrete conforming to Specifications.

D. Acceptance of Structure:

1. Acceptance of structure for dimensional tolerances, appearance, and strength will be based on ACI-301, Chapter 18.
2. Remove and replace concrete which does not meet acceptance criteria.

3.11 PATCHING AND REPAIRING DEFECTIVE CONCRETE

A. General:

1. Rewettable bonding agent may be used only in areas not subject to wet conditions.
2. Patching compound may only be used for concrete not exposed to view.

B. Repairing Formed Surfaces:

1. Surface Defects Requiring Repair:
 - a. Color and texture irregularities.
 - b. Honeycomb, air bubbles, rock pockets, and spalls.
 - c. Fins, burrs and other surface projections.
 - d. Cracks.
 - e. Stains and other discolorations that cannot be removed by cleaning.
2. Patch defective areas and tie holes immediately after removal of forms.
3. Cut out honeycomb, rock pockets, and voids over 1/4 inch down to solid concrete but not less than 1 inch depth.
4. Make edges of cuts perpendicular to concrete surface.
5. Clean and dampen area including 6 inches of surrounding surface with water.
6. Apply bonding grout by brushing into surface, after surface water has evaporated.
7. Place patching mortar or patching compound before grout has set or dried.
8. Compact patching material in place and strike off slightly higher than surrounding surface.
9. Finish after minimum of one hour to match surrounding surface.
10. Flush out form tie holes, fill with patching mortar, patching compound, or precast cement cone plugs secured in place with bonding compound.
11. Cure repair areas by same methods as surrounding concrete or keep continuously damp for 7 days.

C. Repairing Unformed Surfaces:

1. Surface Defects Requiring Repair:
 - a. Fine crazing cracks.
 - b. Cracks larger than 0.012 inch wide or cracks which penetrate to reinforcing.
 - c. Cracks penetrating completely through non-reinforced sections.
 - d. Spalling, popouts, honeycomb, and rock pockets.
 - e. High and low areas in slabs.
2. Correct high areas in hardened concrete by grinding after concrete has cured at least 14 days.
3. Correct high and low areas during, or immediately after, completion of initial floating operations by cutting high areas and by placing fresh concrete in low areas.

4. Repair defective areas, except isolated random cracks and single holes not exceeding 1 inch diameter, by cutting out and replacing with patching mortar or patching compound.
 - a. Remove defective areas to sound concrete with clean, square cuts.
 - b. Dampen concrete surfaces in contact with patching material and apply bonding grout by brushing into surface, after surface water has disappeared.
 - c. Place patching mortar or patching compound before grout has set or dried.
 - d. Compact and finish to blend with adjacent finished concrete.
 - e. Cure in same manner as adjacent concrete.

 5. Repair isolated random cracks and single holes not over 1 inch diameter with patching mortar.
 - a. Groove top of cracks and cut out holes to sound concrete and clean area.
 - b. Dampen cleaned surfaces and apply bonding grout by brushing into surface, after surface water has disappeared.
 - c. Place patching material before bonding grout is set or dry.
 - d. Compact in place and finish to match adjacent concrete.
 - e. Keep patched area continuously moist for not less than 72 hours.
- D. Structural Repairs: Contractor shall proposed materials, methods, and procedures to the Architect for review and approval prior to proceed with structural repairs.

3.12 PROTECTION

- A. Protect finished work in accordance with Division 1.
- B. Protect concrete from construction traffic, weather, or mechanical damage for 14 days after placing.
- C. Provide raised runways for traffic areas.
- D. Protect concrete from staining.

END OF SECTION 033000

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SECTION 033053 - MISCELLANEOUS CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes miscellaneous cast-in-place concrete, including reinforcement, concrete materials, mixture design, placement procedures, and finishes. This is for all concrete not covered by Sections in related requirements, for example, fence posts, on grade equipment pads etc.
- B. Related Requirements:
 - 1. Section 312000 "Earth Moving" for drainage fill under slabs-on-grade.
 - 2. Section 321313 "Concrete Paving" for concrete pavement and walks.
 - 3. Section 033000 "Cast In Place Concrete" for structural concrete, slabs-on-grade and elevated deck concrete fill.
 - 4. Section 032000 "Concrete Reinforcement" for steel reinforcing of concrete.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Design Mixtures: For each concrete mixture.

1.4 QUALITY ASSURANCE

- A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. Comply with the following sections of **ACI 301 (ACI 301M)** unless modified by requirements in the Contract Documents:
 - 1. "General Requirements."

2. "Formwork and Formwork Accessories."
3. "Reinforcement and Reinforcement Supports."
4. "Concrete Mixtures."
5. "Handling, Placing, and Constructing."
6. "Lightweight Concrete."

B. Comply with **ACI 117 (ACI 117M)**.

2.2 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, **Grade 60 (Grade 420)**, deformed.

2.3 CONCRETE MATERIALS

A. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

B. Cementitious Materials:

1. Portland Cement: ASTM C 150/C 150M, Type II.
2. Fly Ash: ASTM C 618, Class C or F.
3. Slag Cement: ASTM C 989/C 989M, Grade 100 or 120.
4. Blended Hydraulic Cement: ASTM C 595/C 595M, Type IP, portland-pozzolan cement.

C. Normal-Weight Aggregate: ASTM C 33/C 33M, 1" nominal maximum aggregate size.

D. Air-Entraining Admixture: ASTM C 260/C 260M.

E. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

F. Water: ASTM C 94/C 94M.

2.4 RELATED MATERIALS

A. Vapor Retarder: Polyethylene sheet, ASTM D 4397, not less than **15 mils** thick; or plastic sheet, ASTM E 1745, Class C.

B. Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork.

2.5 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.
- B. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth or cotton mats.
- C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- D. Water: Potable.
- E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.
- F. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

2.6 CONCRETE MIXTURES

- A. Comply with **ACI 301 (ACI 301M)**.
- B. Normal-Weight Concrete:
 - 1. Minimum Compressive Strength: **4000 psi (27.6 MPa)** at 28 days, uno on plans
 - 2. Maximum W/C Ratio: 0.40, uno on plans
 - 3. Cementitious Materials: Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not more than 25 percent.
 - 4. Slump Limit: **4 inches (100 mm)**, plus or minus **1 inch (25 mm)**.
 - 5. Air Content: Maintain within range permitted by **ACI 301 (ACI 301M)**. Do not allow air content of trowel-finished floor slabs to exceed 3 percent.

2.7 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and ASTM C 1116/C 1116, and furnish batch ticket information.
 - 1. When air temperature is above **90 deg F (32 deg C)**, reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 - 1. For mixer capacity of **1 cu. yd. (0.76 cu. m)** or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 - 2. For mixer capacity larger than **1 cu. yd. (0.76 cu. m)**, increase mixing time by 15 seconds for each additional **1 cu. yd. (0.76 cu. m)**.
 - 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mix type, mix time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 FORMWORK INSTALLATION

- A. Design, construct, erect, brace, and maintain formwork according to **ACI 301 (ACI 301M)**.

3.2 EMBEDDED ITEM INSTALLATION

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

3.3 VAPOR-RETARDER INSTALLATION

- A. Install, protect, and repair vapor retarders according to ASTM E 1643; place sheets in position with longest dimension parallel with direction of pour.
 - 1. Lap joints **6 inches (150 mm)** and seal with manufacturer's recommended adhesive or joint tape.

3.4 STEEL REINFORCEMENT INSTALLATION

- A. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
 - 1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

3.5 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 Architect.
- C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness, as follows:
 - 1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut **1/8-inch- (3.2-mm-)** wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

- 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.

3.6 CONCRETE PLACEMENT

- A. Comply with **ACI 301 (ACI 301M)** for placing concrete.
- B. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of **ACI 301 (ACI 301M)**.
- C. Do not add water to concrete during delivery, at Project site, or during placement.
- D. Consolidate concrete with mechanical vibrating equipment according to **ACI 301 (ACI 301M)**.
- E. Equipment Bases and Foundations:
1. Coordinate sizes and locations of concrete bases with actual equipment provided.
 2. Construct concrete bases **4 inches (100 mm)** high unless otherwise indicated; and extend base not less than **6 inches (150 mm)** in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated or unless required for seismic anchor support.
 3. Minimum Compressive Strength: **4000 psi (27.6 MPa)** at 28 days, uno on plans.
 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor them into structural concrete substrate.
 6. Prior to pouring concrete, place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 7. Cast anchor-bolt insert into bases. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.7 FINISHING FORMED SURFACES

- A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections exceeding **1/2 inch (13 mm)**.
1. Apply to concrete surfaces not exposed to public view.
- 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 **1/8 inch (3 mm)**.

1. Apply to concrete surfaces exposed to public view, or to be covered with a coating or covering material applied directly to concrete.
- C. Rubbed Finish: Apply the following rubbed finish, defined in **ACI 301 (ACI 301M)**, to smooth-formed-finished as-cast concrete where indicated:
1. Smooth-rubbed finish.
 2. Grout-cleaned finish.
 3. Cork-floated finish.
- 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.

3.8 FINISHING UNFORMED SURFACES

- A. General: Comply with ACI 302.1R for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Screed surfaces with a straightedge and strike off. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane before excess moisture or bleedwater appears on surface.
1. Do not further disturb surfaces before starting finishing operations.
- C. Scratch Finish: Apply scratch finish to surfaces indicated and surfaces to receive concrete floor topping or mortar setting beds for ceramic or quarry tile, portland cement terrazzo, and other bonded cementitious floor finishes unless otherwise indicated.
- D. Float Finish: Apply float finish to surfaces indicated, to surfaces to receive trowel finish, and to floor and slab surfaces to be covered with fluid-applied or sheet waterproofing, fluid-applied or direct-to-deck-applied membrane roofing, or sand-bed terrazzo.
- E. Trowel Finish: Apply a hard trowel finish to surfaces indicated 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.
- F. Trowel and Fine-Broom Finish: Apply a partial trowel finish, stopping after second troweling, to surfaces indicated and to surfaces where ceramic or quarry tile is to be installed by either thickset or thinset methods. Immediately after second troweling, and when concrete is still plastic, slightly scarify surface with a fine broom.
- G. Slip-Resistive Broom Finish: Apply a slip-resistive finish to surfaces indicated and to exterior concrete platforms, steps, and ramps. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.

3.9 CONCRETE PROTECTING 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 **ACI 301 (ACI 301M)** for hot-weather protection during curing.
- B. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching **0.2 lb/sq. ft. x h (1 kg/sq. m x h)** 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. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- D. Curing Methods: Cure formed and unformed concrete for at least seven days 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 **12-inch (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 **12 inches (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.
 - 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 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.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Tests: Perform according to **ACI 301 (ACI 301M)**.
 - 1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding **5 cu. yd. (4 cu. m)**, but less than **25 cu. yd. (19 cu. m)**, plus one set for each additional **50 cu. yd. (38 cu. m)** or fraction thereof.

2. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. (76 cu. m) or fraction thereof of each concrete mixture placed each day.

END OF SECTION 033053