

SECTION 03300

CONCRETE

PART 1 - GENERAL

1.1 Summary

A. This Section includes concrete and related items.

B. Related Work Specified Elsewhere

Concrete Formwork.....Section 03100
Concrete Reinforcement.....Section 03200
Concrete Curb, Gutter, Sidewalk, and Driveways.....Section 03310

1.2 Quality Assurance

A. Reference Standards and Specifications

1. American Concrete Institute (ACI)

ACI 211.1 - Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete.

ACI 301 - Specifications for Structural Concrete for Buildings.

ACI 304 - Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete.

ACI 305 - Committee Report on Hot-Weather Concreting.

ACI 306 - Committee Report on Cold-Weather Concreting.

ACI 308 - Recommended Practice for Curing Concrete.

ACI 309 - Recommended Practice for Consolidation of Concrete.

ACI 318 - Building Code Requirements for Reinforced Concrete.

ACI 350 – Code Requirements for Environmental Engineering Concrete Structures and Commentary

2. American Society for Testing and Materials (ASTM)

ASTM C31 - Making and Curing Concrete Test Specimens in the Field.

ASTM C33 - Concrete Aggregates.

ASTM C39 - Compressive Strength of Cylindrical Concrete Specimens.

ASTM C40 - Organic Impurities in Fine Aggregates for Concrete.

ASTM C42 - Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

ASTM C88 - Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.

ASTM C94 - Ready-Mixed Concrete.

ASTM C114 - Methods for Chemical Analysis of Hydraulic Cement.

ASTM C117 - Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing.

ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.

ASTM C142 - Clay Lumps and Friable Particles in Aggregates.

ASTM C143 - Slump of Portland Cement Concrete.

ASTM C150 - Portland Cement.

ASTM C172 - Sampling Freshly Mixed Concrete.

ASTM C192 - Making and Curing Concrete Test Specimens in the Laboratory.

ASTM C231 - Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

ASTM C233 - Testing Air-Entraining Admixtures for Concrete.

ASTM C260 - Air-Entraining Admixtures for Concrete.

ASTM C289 - Potential Reactivity of Aggregates (Chemical Method).

ASTM C295 - Petrographic Examination of Aggregates for Concrete.

ASTM C309 - Liquid Membrane-Forming Compounds for Curing Concrete.

ASTM C430 - Fineness of Hydraulic Cement by the No. 325 (45- μ m) Sieve.

ASTM C494 - Chemical Admixtures for Concrete.

ASTM C566 - Total Moisture Content of Aggregate by Drying.

ASTM D1751 - Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction. (Nonextruding and Resilient Bituminous Types.)

ASTM D1752 - Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

2. Concrete Plant Mixer Standards of the Plant Mixer Manufacturers Division Concrete Plant Manufacturers Bureau.

3. Concrete Plant Standards of the Concrete Plant Manufacturers Bureau.

4. Corps of Engineers Specification for Nonshrink Grout, CRD-C621.

5. Federal Specification (FS)

TT-S-227E - Sealing Compound: Elastomeric Type, Multicomponent (for Caulking, Sealing, and Glazing in Buildings and Other Structures).

6. National Bureau of Standards (NBS) Specifications for Scales.

7. National Ready-Mix Concrete Association, "Truck Mixer, and Agitator Standards of the Truck Mixer Manufacturers Bureau."

B. Acceptance Testing of Concrete During Construction

1. A testing laboratory will be selected and paid by the Owner to perform the required compressive strength tests and statistical evaluations of concrete being used in the Work.

2. The Laboratory will sample, cure and test concrete cylinders in accordance with ASTM C31, C192 and C39, testing two cylinders at 7 days of age and two at 28 days of age.

3. The Laboratory will sample a minimum of one set of concrete cylinders per day's placement or one for each 50 cubic yards for larger placements.

1.3 Submittals

A. Submit as specified in Section 1330.

B. Include, but not limited to, product data and Shop Drawings of the following:

1. Nonshrink grouts.

2. Admixtures.

3. Bonding agents.

4. Curing agents.

5. Concrete floor hardeners, sealers, and coloring compounds.

6. Expansion joint materials.

7. Expansion joint sealants.

8. Waterstops.

C. Mill Certificates

1. Submit to Engineer a minimum of one copy for each cement shipment.

D. Concrete Mix Design Proportions

1. Submit as specified in PART 2, paragraph 2.1.D - Mix Proportions, this Section.
2. Submit for each mix design.
3. Resubmit for any change in each mix design.

E. Production Test Reports: Submit as specified in DIVISION 1 and PART 2, paragraph 2.1.E - Measurement of Materials, this Section.

F. Concrete Plant Certificate: Submit current plant certification showing the concrete plant is certified by the National Ready Mixed Concrete Association (NRMCA).

PART 2 - MATERIALS

2.1 Concrete

A. Materials

1. Portland cement Type V. Conform to ASTM C150.
2. **Fine Aggregate**
 - a. Conform to ASTM C33.
 - b. Approved service record of 3 years with a history indicating that the fine aggregate is not chemically reactive.
 - c. For a new fine aggregate source, or when 3 years' approved service records are not available, or when the service records are unacceptable; the aggregate shall be evaluated for potential reactivity. Aggregate must be considered innocuous in accordance with petrographic examination by ASTM C295 and tests conforming to ASTM C289.

- d. Fine aggregate considered deleterious or potentially deleterious shall not be used without approval.
- e. Maintain fine aggregate free of ice and frozen lumps.

3. Coarse Aggregate

a. Conform to ASTM C33

(1) Limits for deleterious substances and physical property requirements shall conform to Table 3 and applicable class designation 5S, 5M or 1N.

b. Approved service record of 3 years with a history indicating that the coarse aggregate is not chemically reactive.

c. For a new coarse-aggregate source, when 3 years' approved service records are not available, or when the service records are unacceptable; the aggregate shall be evaluated for potential reactivity. Aggregate must be considered innocuous in accordance with petrographic examination by ASTM C295 and tests conforming to ASTM C289.

d. Coarse aggregate considered deleterious or potentially deleterious shall not be used without approval.

e. Blast furnace slag will not be permitted.

f. Maintain coarse aggregate free of ice and frozen lumps.

g. Grading Requirements

(1) From 1 inch to No. 4 for all concrete unless otherwise specified.

4. Mixing Water

a. Only potable water will be acceptable.

5. Admixtures

a. Water-Reducing Type

- (1)** Conform to ASTM C494, Type A.
- (2)** Conform to manufacturer's recommendations for use.
- (3)** Technical assistance of the manufacturer's field representative shall be furnished upon request.

b. Air-Entraining Type

- (1)** Conform to ASTM C260.
- (2)** Conform to manufacturer's recommendations for use.
- (3)** Technical assistance of the manufacturer's field representative shall be furnished upon request.
- (4)** Testing of air-entraining admixtures shall conform to ASTM C233.

c. Other Admixtures: Used only with Engineer's written concurrence.

- (1)** Water-Reducing, Retarding Type: Conform to ASTM C494, Type D, and shall not contain any chloride ions added during manufacture.

d. Storage

- (1)** Admixtures shall be stored in such a manner as to avoid contamination, evaporation, freezing, temperature changes, settling, or any damage, which would adversely affect their characteristics.

B. Laboratory Testing of Materials for Use in Concrete

- 1.** An approved independent testing laboratory shall be selected and paid by Contractor to perform all required quality control tests of materials proposed for use in the production of concrete and to determine mix proportions when laboratory trial batches are required.
- 2.** If requested by the Owner, Contractor shall deliver representative Samples of all proposed concrete materials to the laboratory for the following testing:
 - a. Fine Aggregate**
 - (1)** ASTM C33.
 - (2)** ASTM C40.
 - (3)** ASTM C88.
 - b. Coarse Aggregate**
 - (1)** ASTM C33.
 - (2)** ASTM C88.
 - c.** Air-entraining admixture shall be tested conforming to ASTM C233.
- 3.** The laboratory test results shall be part of the design mix as specified in this PART 2, paragraph 2.1.D. - Mix Proportions, this Section.

C. Concrete Qualities Required

- 1. Compressive Strength**
 - a.** Minimum 28-day compressive strength = 4,000 psi for all construction.
 - b.** Compressive-strength determinations shall be made from 4" diameter x 8" long concrete cylinders tested in accordance with ASTM C39.

2. Slump of concrete shall be 4 inches, ± 1 inch as tested in accordance with ASTM C143.
3. Air Content: 4% to 6% as tested in accordance with ASTM C231.
4. Minimum Cement Content: 600 pounds per cubic yard.
5. Water-Cement Ratio: 0.45.

D. Mix Proportions

1. Concrete shall be homogeneous, readily placeable, and uniformly workable; proportioned to conform to ACI 211.1.
2. Mix proportions for all concrete, unless otherwise specified, shall be selected on the basis of laboratory trial mix design, or historical records of compressive strength.

a. Laboratory Trial Batch: All such Work shall be performed by the laboratory as specified in PART 2, paragraph 2.01.B. - Laboratory Testing of Materials for Use in Concrete, this Section.

(1) Laboratory trial batches shall be used to establish a water-cement ratio, compression-strength curve with at least three points, each representing the strength of a separate trial batch. At least one point shall be above and one below the strength required. Each point on the curve shall represent the average of at least three cylinders tested at 28 days or an earlier age when approved by Engineer. The slump and air content shall be at the maximum limits specified in PART 2, paragraph 2.01.C. - Concrete Qualities Required, this Section.

(2) A point on the water-cement ratio, compressive-strength curve shall be selected that will provide an average strength at least 1,200 psi greater than the specified minimum strength.

(3) Submit the following test data to Engineer for approval prior to placing concrete.

(a) Fine Aggregate

- 1.** ASTM C33.
- 2.** ASTM C40.
- 3.** ASTM C88.
- 4.** ASTM C117.
- 5.** ASTM C136.
- 6.** ASTM C142.
- 7.** Fineness modulus.
- 8.** ASTM C295 and ASTM 289 or approved service records.

(b) Coarse Aggregate

- 1.** ASTM C33.
- 2.** ASTM C88.
- 3.** ASTM C136.
- 4.** ASTM C142.
- 5.** ASTM C295 and ASTM C289 or approved service records.

(c) Cement

- 1.** Mill certificate.

(d) Concrete

- 1.** Fine and coarse aggregate, water and cement sources.
- 2.** Laboratory mix proportions, slump and air content.
- 3.** Water-cement ratio, compressive-strength curve.

b. Historical Records: In lieu of laboratory trial batches, the Contractor shall submit historical compressive strength data which demonstrates the mixture meets the strength criteria for proportioning presented in ACI 318-5.2.

- 3.** Prior to placing any concrete, the laboratory selected by the Contractor shall report the results of the testing and mix designs to the following:
 - a.** Resident Project Representative, Field Office (one copy).
 - b.** Contractor (copies as required).
 - c.** Concrete Supplier (copies as required).

E. Measurement of Materials

1. General Requirements

- a.** Conform to ACI 304.
- b.** Beam or springless dial-type scale conforming with NBS - "Specifications for Scales."
- c.** Volumetric measurement of water shall be performed with an approved automatic valve.

2. Concrete Plant Scale Accuracy and Calibration Frequency

- a. The concrete plant scales shall be accurate to +0.4% of the capacity of the scale.
- b. The scales shall be calibrated at intervals as specified in PART 3, paragraph 3.09 - Testing, this Section.

3. Individual Batch Accuracy

- a. Cement: $\pm 1.0\%$.
- b. Water: $\pm 1.0\%$ by volume or weight.
- c. Aggregates: $\pm 2.0\%$.
- d. Admixtures: $\pm 3.0\%$ by volume or weight.

F. Mixing and Delivery

- 1. Conform to ACI 304.
- 2. Cement temperature, when added to mix, shall not exceed 170°F.
- 3. Adjust the amount of mix water to compensate for the moisture content of the aggregates.
- 4. **Concrete Plant**
 - a. Conform to "Concrete Plant Mixer Standards of the Plant Mixer Manufacturers Division Concrete Plant Manufacturers Bureau" and "Concrete Plant Standards of the Concrete Plant Manufacturers Bureau."
 - b. Charge with 5% to 10% of the mixing water both in advance and after the addition of aggregates and cement.
 - c. Charge with remaining water uniformly with the other materials.

- d. Avoid charging in excess of manufacturer's rating.
- e. Discharge mixed concrete completely prior to recharging.

f. Mixing Time

- (1) Start immediately when all ingredients, except the last of the water, are in the mixer.
- (2) Minimum mixing time shall conform with mixer manufacturer's instructions, but not be less than the following:

<u>Capacity of Mixer Cubic Yards</u>	<u>Minimum Time of Mixing</u>
1 or less	1 minute
2	1 minute, 15 seconds
3	1 minute, 30 seconds
4	1 minute, 45 seconds
5	2 minutes
6	2 minutes, 15 seconds

Add 15 seconds' mixing time for each additional cubic yard of concrete.

5. Mixing of Concrete at Plant Off Jobsite

- a. Mix concrete in central mixer or truck mixer. Transport in truck mixer turning at agitation speeds only.
- b. Water added to concrete having a slump below the specified minimum shall be at Contractor's risk. If the water added produces a slump greater than the specified maximum, the concrete will be rejected. If water is added, the concrete shall be remixed for a minimum of 25 revolutions.
- c. Truck mixer shall conform to "Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau" of the National Ready-Mix Concrete Association.

- d. Ready-mixed concrete shall be produced and delivered conforming to ASTM C94 as applicable.
 - e. Contractor shall furnish Owner with a concrete delivery ticket for each load of concrete. The ticket shall have the following information recorded:
 - (1) Ticket number.
 - (2) Time batched.
 - (3) Time arrived on jobsite.
 - (4) Time discharge started.
 - (5) Time completed delivery.
 - (6) Mix number.
 - (7) Amount of all water added at jobsite by Contractor.
6. Plant and truck mixer uniformity shall be tested according to ASTM C94. Frequency of tests shall be as specified in PART 3, this Section.

2.2 Grout

A. Grout for Dry Packing

- 1. **Volume:** 1 part portland cement to 2 parts sand.
- 2. Keep water to a minimum as required for placing by the dry packing method.
- 3. Place after the mixed grout has been allowed to stand for 2 hours.
- 4. The sand and cement shall be as specified for concrete.

B. Flowable Nonshrinking Grout

1. Required for setting handrail posts, for setting equipment recommended by the manufacturer to be set with nonshrinking grout, and in other places indicated.
2. Grout shall conform to Corps of Engineers specification for Nonshrink Grout, CRD-C621.
3. Grout shall be nonmetallic, as manufactured by one of the following:
 - a. L and M Construction Chemicals, Inc. - Crystex.
 - b. U. S. Grout Corporation - Five Star Grout.
 - c. Master Builder's Company - Masterflow 713 Grout.
 - d. Sauereisen Cements Company - Sauereisen F-100.
 - e. Gifford-Hill & Company - Supreme Grout.
4. Prepare and place conforming to manufacturer's printed instructions.
5. For equipment bases, the concrete surfaces shall be sandblasted or roughened with a chipping hammer prior to grouting. The foundation plates shall be cleaned of any grease, oil, paint, primers, or epoxy coatings.

C. Grout for Bonding

1. Proportion (by weight): 1 part cement to 1-1/2 parts sand.
2. Keep water to a minimum.

2.3 Bonding Agent

- A.** Provide moisture-insensitive, epoxy-resin bonding agent as manufactured by one of the following:
1. A. C. Horn, Inc. - Epoxitite.
 2. Euclid Chemical Company - Euco Epoxy.
 3. Sika Chemical Company - Sikastix 370.
 4. L&M Construction Chemicals, Inc. - Epobond.

2.4 Concrete Accessories

A. Water Stops

1. Serrated virgin polyvinyl chloride equal to one of the following:
 - a. Four Seasons, Inc. - Horn Durajoint Type 3.
 - b. Vulcan Metal Products Company - Vulco 8013.
 - c. Greenstreak – Model No. 732

B. Expansion Joints

1. **Expansion Joint Filler:** Premolded cork of thickness indicated and conforming to ASTM D1752, Type III, self-expanding cork. Unless indicated to be asphalt-impregnated fiber.
2. **Expansion Joint Filler:** Preformed asphalt-impregnated fiber of thickness indicated and conforming to ASTM D1751. Use where indicated.
3. **Bond Breaker:** Polyethylene strip.

4. Joint Sealant:

- a.** Use 2-component, self-leveling urethane conforming to FS TT-S-227E as manufactured by one of the following:
 - (1)** A. C. Horn Inc. - Duraseal-U.
 - (2)** Pecora Inc. - Urexpan NR-200.
 - (3)** Sonneborn - SL-2 Sealant.
- b.** Prime joints with manufacturer's primer.

C. Dovetail Anchor Slots

- 1.** 24-gage zinc alloy, 1" (25 mm) wide back x 1" deep x 5/8" throat as manufactured by one of the following:
 - a.** Gateway Products.
 - b.** Heckmann Building Products, Inc.
 - c.** Hohmann & Barnard, Inc.

2.5 Curing Agent

- A.** Liquid membrane-forming compound conforming to ASTM C309, Type 1. Curing agent shall be VOC compliant with maximum 2.9 lbs/gal (350 g/l), or less where area regulations are more stringent. ASTM C309, Type 2 shall be used as specified in PART 3, paragraph 3.05 - HOT WEATHER CONCRETING, this Section.

PART 3 - EXECUTION

3.1 Preparation for Concrete Placement

- A. Openings Through Concrete:** Provide openings through concrete as indicated and for the proper installation of all equipment, piping, wiring and similar items, installed under this Contract.

B. Installation of Embedded Items

- 1.** Provide for accurate installation of embedded items installed under this Contract.
- 2.** Embedded items shall be as indicated or specified, or as selected by Contractor and approved by Engineer.
- 3.** During cold weather, protect pipe sleeves from moisture, which may freeze, expand, and crack the sleeve and concrete structure.
- 4.** Grease or tape anchor bolt threads to protect from concrete splatter.

C. Installation of Joints

1. Construction Joints

a. Location

- (1)** Locate joints, which are not indicated or specified, in conformance with ACI 318.
- (2)** Obtain Engineer's approval of joints located by Contractor prior to preparation of reinforcing steel drawings.

b. Preparation and Installation

- (1)** Clean and break laitance or other foreign material from bonding surface.
- (2)** Tighten forms remaining in place (where applicable) to prevent seepage between forms and hardened concrete.
- (3)** Provide water stops and shear keys as indicated or specified and as required in any new construction joint requested by Contractor.

c. Waterstops

- (1)** Install in all construction joints where indicated.
- (2)** Install conforming to manufacturer's printed instructions.
- (3)** All joints and splices of PVC waterstop shall be 100% fused.

2. Expansion Joints

- a.** Install as indicated.
- b.** Reinforcement bars will not extend through expansion joints unless otherwise indicated.
- c.** Where joint sealant is indicated, completely cover the top surface of the joint filler with a polyethylene strip bond breaker prior to sealing joint.
- d.** Seal top of expansion joint with joint sealant applied conforming to manufacturer's instructions. Depth of sealant shall be one-half the joint width unless otherwise indicated. During cold weather, protect joint from moisture prior to installation of joint sealant.

3. Dovetail Anchor Slots: Install as indicated or specified.

D. Cutting and Bonding to Existing Concrete

1. Cutting Existing Concrete

- a.** Use methods and equipment that will avoid damage to adjacent parts of the structure from heavy blows or vibration.
- b.** Cut existing concrete with power concrete saw where possible to prevent spalling and chipping and to form neat, straight edge.

- c. Remove all loose or cracked pieces resulting from cutting existing concrete, leaving only sound, undamaged concrete adjacent to new Work.
- d. Leave access opening edges with a neat, true grout surface to the opening size indicated.
- e. Cut reinforcing steel with sufficient length remaining (approximately 30-bar diameters) for bending and lapping into new construction.

2. Bonding to Existing Concrete

- a. Roughen concrete by use of a pneumatic chipping hammer or other approved means.
- b. Thoroughly clean the concrete surface and apply the bonding agent. Place the fresh concrete after the bonding agent becomes tacky.

3.2 Placing of Concrete

A. Conventional Placing

1. General Requirements

- a. Conform to ACI 304.
- b. Bonding surfaces shall be clean, free of laitance and foreign materials.
- c. Face horizontal bonding surfaces with 1-inch-thick coat of fresh "grout for bonding." Wet all other surfaces.
- d. Place concrete on properly prepared and unfrozen subgrade and only in dewatered excavation and forms.
- e. Use forms for all concrete except where otherwise indicated or specified.
- f. Do not place concrete that has partially hardened or has been contaminated by foreign materials.

- g.** Prevent mud or foreign materials from entering the concrete or forms during placement operations.

2. Conveying

- a.** Convey concrete from the mixer and deposit in place by methods, which will prevent the segregation or loss of materials.
- b.** Equipment for chuting, pumping, and pneumatically conveying concrete shall be of such size and design as to provide a practically continuous flow of concrete at the delivery end.
- c.** Aluminum conveying equipment shall not be used.

3. Depositing

- a.** Place concrete in continuous horizontal lifts not to exceed 2 feet, and place concrete against bulkheads and keyways at vertical joints.
- b.** Maximum free drop of concrete shall be 5 feet, in walls 10 inches or less in thickness, with 1-foot additional drop allowed for each inch of wall thickness over 10 inches, with a maximum drop of 10 feet.

4. Consolidation of Concrete

- a.** Consolidate concrete in conformance with ACI 309. Characteristics and application of concrete vibrators shall be as set forth in Table 5.1.4.
- b.** Provide an adequate number of vibrators of sufficient capacity to keep up with the maximum rate of concrete placement. Keep on hand adequate standby equipment in good operating condition.
- c.** Vibrate concrete only until the concrete is thoroughly consolidated and the voids filled, as evidenced by the leveled appearance of the concrete at the exposed surface and the embedment of the surface aggregate.

- d.** Insert internal vibrators vertically to the full depth of the layer being placed and into the previous layer. Do not drag vibrators through the concrete. Insert and withdraw vibrator slowly with the vibrator running continuously so that no hole will be left in the concrete. Do not flow concrete from one location to another by use of a vibrator.
- e.** Consolidate concrete layer to full depth when using a surface vibrator. Use thinner layers or a more powerful vibrator if necessary to achieve complete consolidation.
- f.** Use form vibrators only where sections are too thin or where sections are inaccessible for internal vibrators.

5. Time Requirements

- a.** Place concrete at a sufficient rate to assure that lifts below have not taken initial set before fresh concrete is deposited.
- b.** Place concrete within 45 minutes after mixing. This period may be extended to 1 hour and 30 minutes provided that the combined air temperature, relative humidity, and wind velocity are such that the plasticity of the fresh concrete is satisfactory for placement and consolidation, and that the specified mixing water is not exceeded. Concrete, which has partially set, shall not be retempered but shall be discarded.

6. Placing Concrete at Joints

- a.** Bed horizontal joints with 1 inch of grout for bonding.
- b.** Take precautions to ensure tight, well-bonded construction joints with no air pockets or voids.
- c.** Take special precautions to avoid bending or displacing waterstop while placing concrete around it.
- d.** Delay construction at a joint a minimum of 16 hours where placement is continued past joint, except where otherwise indicated.

3.3 Finishing

A. Unformed Surfaces

1. Screed Finish

- a.** Use as first stage for all concrete finishes.
- b.** Use as final finish on surfaces that will be covered by additional concrete, grout placement, or mortar setting bed except as otherwise specified.
- c.** Immediately after screeding, use a wood float, darby, or bullfloat to eliminate high and low spots and to embed large aggregate. This shall be done in a manner to produce even, uniform surfaces so that surface irregularities do not exceed 3/8 inch in 10 feet when used as final finish.

2. Floated Finish

- a.** Use as second stage of broomed or troweled finish.
- b.** Float with mechanical float. Hand floating will be permitted only in areas inaccessible to mechanical float.
- c.** On surfaces not to receive troweled finish, finish with wood or cork float after mechanical floating to a true uniform surface so that surface irregularities do not exceed 1/8 inch in 10 feet, except at floor drains.

3. Broomed Finish

- a.** Use as final finish on all outdoor concrete surfaces subject to pedestrian and/or vehicle traffic.
- b.** After floated finish, draw a stiff bristle broom across the surface making uniform corrugations, perpendicular to the direction of traffic, not more than 1/16 inch deep.

4. Troweled Finish

- a.** Use as final finish on all other unformed surfaces not otherwise indicated or specified.
- b.** Trowel with steel trowel, mechanical or hand, to obtain a smooth, dense finish. The final troweling shall be done after the concrete has become hard enough so that no mortar adheres to the edge of trowel and a ringing sound is produced as the trowel passes over the surface.
- c.** Do not trowel before surface water has evaporated or has been removed with a squeegee.
- d.** Finish to a true uniform surface so that surface irregularities do not exceed 1/8 inch in 10 feet, except at floor drains.
- e.** Do not add sand or cement to the floor surface.

B. Formed Surfaces

- 1.** Repair surface defects as specified in PART 3, paragraph 3.03.C. - Repair of Defective Surfaces, this Section.

C. Repair of Defective Surfaces

- 1.** Defined as any concrete surface showing misalignment, rock pockets, poor joints, holes from ties, voids, honeycomb, or any other defective area.
- 2. Repairing**
 - a.** Repair as soon as forms have been removed.
 - b.** Chip surface back to minimum depth of 1/2 inch, chip edges perpendicular to surface, prewet depression and brush with neat cement immediately before patching.
 - c.** Patch surfaces using stiff mortar with same sand-cement ratio as original concrete and with minimum water for placing. Blend with white cement to match concrete color.

- d.** Compact mortar into depressions so that after curing, hole is filled and mortar is flush with surface. Use hammer and ramming rod for compacting the holes.
- e.** Moist-cure for 3 days or use curing compound.
- f.** Engineer shall be notified of areas containing defects or where reinforcing steel is exposed, prior to determination of repair method.

3.4 Curing

- A.** Cure all concrete by one of the following methods in accordance with ACI 308:
 - 1.** Leaving in forms for a minimum of 7 days. Keep formwork wet to prevent drying of concrete surfaces.
 - 2.** Use of saturated bats, soaker hoses, or sprinkler for a minimum of 7 days. Keep concrete continuously wet.
 - 3.** Using one coat of a liquid membrane forming compound conforming to ASTM C309, Type 1. Apply immediately after removal of forms (which have been continuously wet); or in case of a slab, after the concrete has been finished and is hardened sufficiently to walk on.
 - 4.** Using polyethylene sheets applied in full contact with surfaces.
 - 5.** Curing of concrete during hot or cold weather shall conform to PART 3 - HOT WEATHER CONCRETING and COLD WEATHER CONCRETING, this Section.

3.5 Hot Weather Concreting

- A.** Follow the recommendations of ACI 305 if any of the following conditions occur:
 - 1.** When the temperature is 90°F or above.
 - 2.** When the temperature is likely to rise above 90°F within the 24-hour period after concrete placement.

- 3.** When there is any combination of high air temperature, low relative humidity, and wind velocity which would impair either concrete strength or quality.
- B.** Concrete shall have a maximum temperature of 100°F during placement.
- C.** Dampen subgrade and forms with cool water immediately prior to placement of concrete.
- D.** Protect freshly placed concrete immediately after placement so that the rate of evaporation as determined by ACI 305 (Figure 2.1.5) does not exceed 0.2 pound per square foot per hour.
- E.** Protect concrete with suitable insulation if rapidly decreasing nighttime temperatures occur, which would cause thermal shock to concrete placed during warm daytime temperatures.
- F.** Protect the concrete with temporary wet covering during any appreciable delay between placement and finishing.
- G.** Begin curing unformed surfaces immediately after finishing and continue for 24 hours. Curing shall consist of application and maintenance of water-saturated material to all exposed surfaces; horizontal, vertical, and otherwise. After the 24-hour interval, continue curing using one of the following methods:
 - 1.** Moist curing for 6 days.
 - 2.** Application of one coat of curing compound conforming to ASTM C309, Type 2.
 - 3.** Application and maintenance of curing paper or heat-reflecting plastic sheets for 6 more days.
- H.** Begin curing formed concrete immediately after placing. Curing shall consist of keeping forms continuously wet for 24 hours. Thereafter, continue curing using one of the following methods:
 - 1.** Loosen forms and position soaker hose so that water runs down along concrete surfaces. Continue for 6 days.

2. Strip forms and apply curing compound conforming to ASTM C309, Type 2. Do not allow concrete surfaces to dry prior to application of curing compound.

3.6 Cold Weather Concreting

- A. When the temperature is 40°F or is likely to fall below 40°F during the 24-hour period after concrete placement, follow the recommendations of ACI 306 to prevent loss of concrete strength or quality.
- B. Minimum temperature for concrete as mixed shall be as indicated on lines 2, 3, and 4 of Table 1.4.1 of ACI 306. Maximum temperature for concrete as mixed shall be 10°F greater than the corresponding minimum temperature.
- C. Place and maintain concrete so that its temperature is never less than the temperature indicated on line 1 of Table 1.4.1 of ACI 306. Maintain the required temperature for the time duration indicated on Table 1.4.2 of ACI 306.
- D. Monitor temperature of concrete in place at corners or edges of formwork as applicable.
- E. **Air Heaters**
 1. Do not expose concrete to carbon monoxide or carbon dioxide fumes from heaters or engines.
 2. Oil- or coke-burning salamanders will not be permitted.
 3. Heaters shall be ultramatic portable heaters made by the Union Chill Mat Company or approved equal.
 4. Personnel shall be present at all times to maintain safe, continuous operation of heating system.
- F. Control temperature and humidity of protected concrete so that excessive drying of concrete surfaces does not occur.
- G. Calcium chloride will not be permitted as a concrete accelerator or to thaw frozen subgrade prior to concrete placement.

- H. The maximum allowable temperature drop during the first 24-hour period after protection is discontinued shall be as indicated on line 5 of Table 1.4.1 of ACI 306.
- I. Cure the concrete in accordance with Chapter 5 of ACI 306.

3.7 Low-Strength Concrete

A. Low-Strength Concrete

1. Defined as either

- a. Concrete whose average, of any sets of three consecutive 28-day strength tests, is below the required 28-day strength.
- b. Concrete whose individual 28-day strength test (average of two cylinders) is more than 500 psi below the required 28-day strength.

2. Should concrete meet either definition of low-strength concrete as a minimum, the Contractor shall take the following steps:

- a. Increase the cement content. The increase shall be based on a statistical evaluation of the strength data, the design water-cement ratio, compressive-strength curve, and acceptable mix-design literature as follows:
 - (1)** If sufficient concrete has been furnished to accumulate 30 tests, these should be used to establish a new target average strength in accordance with ACI 318, Section 4.3.1.
 - (2)** If less than 30 tests have been made, the new target average strength should be at least as great as the average strength used in the initial selection of the mix proportions. Increase the target average strength based on a statistical evaluation of the available strength data, the design water-cement ratio, compressive-strength curve, and acceptable mix-design literature. If the statistical average equals or exceeds the initial mix-design level, a further increase in the average level is required.

2. Reinforce conforming to typical detail unless otherwise indicated.
3. Equipment bases shall include concrete, reinforcing steel, form work as required, and anchor bolts. Place grout for equipment installed under this Contract.
4. Finish top area of bases between anchor bolts and forms with a troweled finish.

3.9 Testing

A. Field Testing of Concrete Plant and Mixing Trucks

1. The concrete plant shall be inspected and tested to ensure conformance with ACI 304 and the "Concrete Plant Standards of the Concrete Plant Manufacturers Bureau." The scales shall be calibrated at the initial setup and at 3-month intervals thereafter.
2. Mixing trucks shall be inspected and tested to ensure conformance with ACI 304 and "Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau" of the National Ready-Mix Concrete Association. Tests shall be done at initial setup and every 3 months thereafter.
3. Submit test reports when requested.

B. Field Testing of Concrete and Making of Concrete Test Cylinders

1. Contractor shall furnish test equipment, test cylinder molds, and trained personnel to perform all required field tests, make the required concrete test cylinders, and deliver test cylinders to the testing laboratory. The prescribed tests shall be made in the presence of or with the concurrence of the Owner.
2. Concrete sampling for tests and cylinder making shall be done conforming to ASTM C172. Samples shall be taken at random and at the point of truck discharge.

3. Perform the following tests

- a.** Moisture content, ASTM C566. Perform this test a minimum of twice a day and adjust the amount of mix water to compensate for the moisture content of the aggregates.
- b.** Prepare test cylinders conforming to ASTM C31, with not less than one set of cylinders (four cylinders) from each day's placement for each 50 cubic yards or fraction thereof. Test cylinders for compressive strength in accordance with ASTM C39.
- c.** Slump test conforming to ASTM C143. Perform tests on the first batch produced each day, for every 50 cubic yards or fraction thereafter, and with every set of test cylinders. Additional tests shall be run when directed by the Engineer.
- d.** Air content test conforming to ASTM C231. Perform for first batch of day and with each set of test cylinders.
- e.** The batch of concrete being tested for slump or air content shall not be placed until acceptable results are obtained.
- f.** Discard concrete used for slump and air tests.
- g.** Perform concrete and air temperature tests for first batch of day and with each set of test cylinders. Additional readings shall be taken when directed by the Engineer.
- h.** Any batch of concrete with slump or air content not in conformance with Specifications shall be rejected.
- i.** Furnish slump, air content, and temperature test results to the testing laboratory for inclusion in the cylinder test reports.

C. Laboratory Testing of Aggregates and Concrete During Construction

- 1.** An independent testing laboratory will be selected and paid by the Owner to perform the required laboratory tests and statistical evaluations of concrete being used in the Work.
- 2.** Laboratory will sample, cure and test concrete cylinders in accordance with ASTM C31, C192 and C39, testing two cylinders at 7 days of age and two at 28 days of age.
- 3.** Contractor shall have the right to observe all phases of concrete cylinder curing and testing. Should Contractor observe any deviations from the prescribed testing procedures that he considers detrimental to concrete strength test results, he shall immediately notify Owner in writing.
- 4.** Contractor shall assist laboratory in obtaining Samples of fine and coarse aggregate for periodic testing.
- 5.** The Contractor shall make arrangements with the testing laboratory to receive copies of test reports. The cost of providing a maximum of two copies of each report to the Contractor will be paid by the Owner.
- 6.** Should the test results indicate low strength concrete as defined in PART 3, paragraph 3.07 - LOW-STRENGTH CONCRETE, this Section, Contractor shall take immediate corrective action.
- 7.** Should the statistical data indicate an excessive margin of safety, the concrete mix may be modified subject to Engineer's approval.
- 8.** Should the material tests taken during construction indicate nonconformance with the Specifications, the Contractor shall take immediate corrective action.

PART 4 - MEASUREMENT AND PAYMENT – Not Applicable

**** END OF SECTION 03300 ****