

1.02 EARTH FORMS

- A. Earth forms may be permitted only where specifically allowed in the Geotechnical report.
- B. Hand trim sides and bottom of earth forms. Remove loose soil prior to placing concrete.
- C. Where earth forms are used, increase sizes of structural elements shown in the drawings by a minimum of three inches.

1.03 ERECTION – FORMWORK

- A. Erect formwork, shoring and bracing to achieve design requirements, in accordance with requirements of ACI 301.
- B. Provide bracing to ensure stability of formwork. Shore or strengthen formwork subject to overstressing by construction loads.
- C. Coordinate placement of joint devices with erection of concrete formwork and placement of form accessories.
- D. Arrange and assemble formwork to permit dismantling and stripping. Do not damage concrete during stripping.
- E. Align joints and make watertight. Keep form joints to a minimum.
- F. Obtain approval before framing openings in structural members that are not indicated on drawings.
- G. Provide filler and chamfer strips on external corners of beams, joists, columns, and walls where shown on architectural drawings.
- H. Install void forms in accordance with manufacturer's recommendations. Protect forms from moisture or crushing.
- I. Coordinate this section with other sections of work that require attachment of components to formwork.

1.04 APPLICATION - FORM RELEASE AGENT

- A. Apply form release agent on formwork in accordance with manufacturer's recommendations.
- B. Apply prior to placement of reinforcing steel, anchoring devices, and embedded items.

1.05 INSERTS, EMBEDDED PARTS, AND OPENINGS

- A. Provide formed openings where required for items to be embedded in or passing through concrete work.
- B. Locate and set in place items that will be cast directly into concrete.
- C. Coordinate with work of other sections in forming and placing openings, slots, recesses, sleeves, bolts, anchors, other inserts, and components of other work.
- D. Install accessories in accordance with manufacturer's instructions, so they are straight, level, and plumb. Ensure items are not disturbed during concrete placement.
- E. Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.
- F. Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.

1.06 FORM CLEANING

- A. Clean forms as erection proceeds, to remove foreign matter within forms.
- B. Clean formed cavities of debris prior to placing concrete.
 - 1. Flush with water or use compressed air to remove remaining foreign matter. Ensure that water and debris drain to exterior through clean-out ports.
 - 2. During cold weather, remove ice and snow from within forms. Do not use de-icing salts. Do not use water to clean out forms, unless formwork and concrete construction proceed within heated enclosure. Use compressed air or other means to remove foreign matter.

1.07 FORMWORK TOLERANCES

- A. Construct formwork to maintain tolerances required by ACI 301.
- B. Camber slabs per drawings.

1.08 FIELD QUALITY CONTROL

- A. An independent testing agency will perform field quality control tests, as specified in Section 01 45 23 "Tests and Inspections".
- B. Inspect erected formwork, shoring, and bracing to ensure that work is in accordance with formwork design, and to verify that supports, fastenings, wedges, ties, and items are secure.

1.09 FORM REMOVAL

- A. Do not remove forms or bracing until concrete has gained sufficient strength to carry its own weight.
- B. Loosen forms carefully. Do not wedge pry bars, hammers, or tools against finish concrete surfaces scheduled for exposure to view.
- C. Store removed forms to prevent damage to form materials or to fresh concrete. Discard damaged forms.
- D. Remove formwork in such a sequence as to achieve similar concrete surface coloration.

END OF SECTION 03 11 00

REINFORCING STEEL SECTION 03 21 00

PART 1 GENERAL

1.01 SUMMARY

- A. Inclusions:
 - 1. Reinforcing steel for cast-in-place concrete and concrete masonry units.
 - 2. Supports and accessories for steel reinforcement.
- B. Related Sections
 - 1. Section 03 11 00: Concrete Forming
 - 2. Section 03 31 00: Cast-in-Place Concrete.
 - 3. Section 04 24 00: Concrete Unit Masonry Units

1.02 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 A 82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
- E. ASTM A 184/A 184M - Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement.
- F. ASTM A 185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
- G. ASTM A 497/A 497M - Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
- H. ASTM A 615/A 615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
- I. ASTM A 704/A 704M - Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement.
- J. ASTM A 706/A 706M - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.

- K. ASTM A 996/A 996M - Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.
- L. AWS D1.4 - Structural Welding Code - Reinforcing Steel; American Welding Society.
- M. CRSI (DA4) - Manual of Standard Practice; Concrete Reinforcing Steel Institute.
- N. CRSI (P1) - Placing Reinforcing Bars; Concrete Reinforcing Steel Institute.

1.03 SUBMITTALS

- A. Shop Drawings: Only when deviations are made from the contract documents, submit shop drawings under provision of Section 01 31 00 "Project Management and Coordination" 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 certified copies of mill test report of reinforcement materials analysis, indicate physical and chemical analysis.
- D. Welders Certificates: Submit certifications for welders employed on the project, verifying AWS qualifications with the previous 12 months.

1.04 QUALITY ASSURANCE

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

1.05 AIR QUALITY REQUIREMENTS

- A. Comply with the requirements of Section 01 41 00 "Regularity Requirements" as they are applicable to the work of this section, and as though they are repeated verbatim herein.

PART 2 PRODUCTS

2.01 REINFORCEMENT

- A. Reinforcing Steel: ASTM A 615/A 615M Grade 60.
 - 1. Deformed billet-steel bars.
 - 2. Unfinished.

- B. Reinforcing Steel: ASTM A 706/A 706M, deformed low-alloy steel bars.
 - 1. Deformed billet-steel bars.
 - 2. Unfinished.
- C. Steel Welded Wire Reinforcement: ASTM A185/A 185M, plain type.
 - 1. Welded Wire Mat Reinforcing: mesh size and gage as indicated on drawings.
- D. Steel Welded Wire Reinforcement: ASTM A 497, 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. Chairs, Bolsters, Bar Supports, Spacers: Sized and shaped for adequate support of reinforcement during concrete placement, including load bearing pad on bottom to prevent vapor barrier puncture.
 - 3. Provide stainless steel, plastic, or plastic coated steel components for placement within 1½" of weathering surfaces.

2.02 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

3.01 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.
 - 1. 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.
 - 2. Do not displace or damage vapor barrier.
 - 3. Accommodate placement of formed openings.

3.02 FIELD QUALITY CONTROL

- A. An independent testing agency, as specified in Section 01 45 23 "Tests and Inspections", will inspect installed reinforcement for conformance to contract documents before concrete placement.

END OF SECTION 03 21 00

STRUCTURAL CONCRETE WORK

SECTION 03 31 00

PART 1 GENERAL

1.01 SUMMARY:

- A. Inclusions:
 - 1. Provisions set forth in Divisions 0 and 1;
 - 2. Footings for exterior concrete block walls;
 - 3. Placing of bolts, anchors, frames, inserts, etc.;
 - 4. Protection and patching of concrete;
 - 5. Submittal preparation and concrete mix designs;
 - 6. Superplasticizers and admixtures;
 - 7. Control and expansion joints;
 - 8. Clean-up.
- B. Related Sections:
 - 1. Section 03 11 00: Concrete Forming
 - 2. Section 03 21 00: Steel Reinforcing.
 - 3. Section 32 13 13: Site Concrete.

1.02 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 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete; American Concrete Institute International.
- D. ACI 305R - Hot Weather Concreting; American Concrete Institute International.
- E. ACI 306R - Cold Weather Concreting; American Concrete Institute International.
- F. ACI 308R - Guide to Curing Concrete; American Concrete Institute International.
- G. ACI 318 - Building Code Requirements for Structural Concrete and Commentary; American Concrete Institute International.
- H. ASTM C 33 - Standard Specification for Concrete Aggregates.
- I. ASTM C 39/C 39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
- J. ASTM C 94/C 94M - Standard Specification for Ready-Mixed Concrete.

- K. ASTM C 143/C 143M - Standard Test Method for Slump of Hydraulic-Cement Concrete.
- L. ASTM C 150 - Standard Specification for Portland Cement.
- M. ASTM C 173/C 173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
- N. ASTM C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.
- O. ASTM C 494/C 494M - Standard Specification for Chemical Admixtures for Concrete.
- P. ASTM C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
- Q. ASTM C 685/C 685M – Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing.
- R. ASTM C 881/C 881M - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
- S. ASTM C 1059 - Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete.

1.03 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.

1.04 SUBMITTALS

- A. General: Submit in accordance with Section 01 30 00 “Administrative Requirements”.
- B. Shop Drawings: Submit drawings locating slab-on-grade construction joints, control joints, and isolation joints.
- C. Product Data: Submit product data for proprietary products.
- D. Samples:
 - 1. Provide 12 inch by 18-inch concrete sample of smooth rubbed [grout cleaned] [cork float] finishes showing final texture to be expected.
- E. 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 in which the project is located.
 - 3. Specifically indicate where each class of concrete is to be used.
 - 4. Indicate individual and combined aggregate gradations and aggregate source and characteristics.
- F. Test Reports: Submit aggregate and concrete mix test reports from independent testing laboratory as required by Section 01 45 23 "Tests and Inspections".

1.05 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.

1.06 TESTING REQUIREMENTS

- A. Testing will be performed under the provisions of Section 01 45 23 "Tests and Inspections", except as otherwise specified.

1.07 PRE-INSTALLATION CONFERENCE

- A. Conduct pre-installation conference in accordance with Section 01 31 00 "Project Management and Coordination".

1.08 DELIVERY, STORAGE, AND HANDLING

- A. General: Comply with requirements of Section 01 60 00 "Product Requirements".
- 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.

1.09 AIR QUALITY REQUIREMENTS

- A. Comply with the requirements of Section 01 41 00 "Regulatory Requirements" as they are applicable to the work of this section, and as though they are repeated verbatim therein.

PART 2 PRODUCTS

2.01 FORMWORK

- A. Comply with the requirements of Section 03 11 00 "Concrete Forming".

2.02 REINFORCEMENT

- A. Comply with the requirements of Section 03 21 00 "Steel Reinforcing".

2.03 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.
 - 3. [Do not use Type III cement in lightweight structural concrete.]
- B. Aggregate:
 - 1. Coarse Aggregate:
 - a. ASTM C33 for normal weight aggregate.
 - b. ASTM C330 for lightweight aggregate.
 - 2. Fine Aggregate: ASTM C33.
 - 3. Exposed Aggregate: To match Architect's sample.
- 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. 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.
 5. Water-reducing, Retarding: ASTM C494, Type D.
 6. Chemical Corrosion Inhibitor:
 - a. Calcium nitrite in liquid form.
 - b. Acceptable Product: DCI by Grace Construction Products, Cambridge, MA.
- E. Bonding Admixture:
1. Acrylic or styrene butadiene, non-remulsifiable.
 2. Acceptable Products:
 - a. Flex-Con or SBR Latex, Euclid Chemical Company, Cleveland, OH.
 - b. Everbond, L&M Construction Chemicals, Inc., Omaha, NE.
 - c. Acryl Set, Master Builders, Cleveland, OH.
 - d. Intralok, W. R. Meadows, Inc., Elgin IL.
- F. Bonding Grout:
1. Mix consisting of portland cement, part fine sand passing No. 30 mesh sieve, bonding admixture, and water in proportions as recommended by bonding admixture manufacturer.
 2. Minimum 1:1 cement to sand ratio.
 3. Mix to achieve consistency of thick cream.

2.04 CURING MATERIALS

- A. Sheet Curing Materials: ASTM C171; white opaque polyethylene film, white polyethylene coated burlap sheeting, or regular waterproof paper.

2.05 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. Concrese 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.

2.06 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 in which the project is located.
3. Contractor employed testing agency shall not be same firm as Owner employed testing agency.
4. Use concrete of approved mix designs only.
5. 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.
6. Do not place concrete until design mix for that class and type of concrete is reviewed by Architect.
7. Indicate locations in structure where each mix design is to be used.
8. Identify each mix design with code number which will be used on batch tickets.

B. Design Compressive Strengths: 3000 psi (normal weight).

1. Normal Weight Concrete:
 - a. Compressive strength, when tested in accordance with ASTM C 39/C 39M, 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 +/- 1".

- C. Maximum Size of Coarse Aggregate:
1. $\frac{1}{5}$ narrowest dimension between form sides.
 2. $\frac{1}{3}$ depth of slabs.
 3. $\frac{3}{4}$ of minimum clear distance between reinforcing bars, wires, or bundles of bars.
 4. 1 inch maximum for normal weight concrete or $\frac{3}{4}$ inch maximum for light 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.
 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. Maximum permissible water cement ratio: 0.50 unless noted otherwise on drawings.
- G. Admixtures:
1. Only use admixtures which have been tested and approved in mix designs.
 2. Air entraining Admixture:
 - a. Use in concrete exposed to freezing and thawing at any time during construction or in completed structure.
 - b. Use in concrete placed at ambient temperatures below 40 degrees F.
 - c. Tolerance on air content as delivered: Plus or minus 1-1/2 percent.
 3. Conform to air content requirements indicated on Drawings.
- 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/Structural Engineer. Use of admixtures will not relax cold weather placement requirements.

2.07 MIXING

- A. Ready-Mix Concrete:
 1. Comply with ASTM C 94/C 94M.
 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.

2.08 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 1½ hours after mixer is charged in average conditions. Time shall be reduced to one hour during hot weather concreting.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine conditions and proceed with Work.
- 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.

3.02 TESTING

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

3.03 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.

3.04 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."

3.05 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."

3.06 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.

3.07 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 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, embedded parts, and formed construction joint devices will not be disturbed during concrete placement.
- G. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.
- H. Place concrete continuously.
- I. Do not interrupt successive placement; do not permit cold joints to occur.
- J. Maintain surfaces receiving concrete at approximately same temperature as concrete being placed.
- K. Maintain surface of hardened concrete below 100 degrees F.
- L. 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.
- M. 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. 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. 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.
 9. Place concrete without displacing reinforcing and accessories.
- N. 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.

3.08 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.

3.09 FINISHING

- A. General: Provide finishes at specified locations, unless indicated otherwise.
- B. Finishing Formed Surfaces:
 1. Rough Form Finish:
 - a. Leave surfaces with texture imparted by forms, except patch tie holes and defects.
 - b. Remove fins and other projections exceeding 1/4 inch in height.
 - c. Locations: Concrete surfaces not exposed to view.

3.10 CURING

- A. General:
 1. Comply with ACI-308, except as modified or supplemented.
 2. Start immediately after placing and finishing concrete.

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.
 5. Maintain temperature of concrete above 50 degrees F for curing period.
 6. Minimum Length of Curing Period:
 - a. High Early Strength Concrete: 3 days.
 - b. Other Concrete: 7 days.
- B. Acceptable Curing Methods:
1. Concrete to receive Waterproofing or Dampproofing:
 - a. Moist curing, moisture-retaining sheet covering, or chemical curing compounds.
 2. Other Concrete: Moist curing, moisture-retaining sheet covering.
- C. Acceptable Curing Procedures:
1. Moist Curing Unformed Surfaces:
 - a. Fabric Mats: Cover surfaces with wet burlap or other absorptive material which will not discolor concrete; keep continuously wet.
 2. Curing of surfaces which are moist cured for first 24 hours may be cured by other acceptable methods for remaining curing period provided they are not allowed to become dry.

3.11 FIELD QUALITY CONTROL

- A. Field testing will be performed under the provisions of Section 01 45 23 "Tests and Inspections".
- 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. Air Content of Plastic Mix:
 - a. For Normal Weight, Air Entrained Concrete: ASTM C231, pressure method or ASTM C173, volumetric method.
 - b. For Lightweight, Air Entrained Concrete: ASTM C173, volumetric method.
 - c. Make one test each time a set of compressive strength test specimens is made.
 5. 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.
6. 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.
7. Observe conveying, placement and consolidation of concrete for conformance to Specifications.
8. Observe condition of formed surfaces upon removal of formwork prior to repair of surface defects and observe repair of surface defects.
9. Observe curing procedures for conformance with Specifications, record dates of concrete placement, start of preliminary curing, start of final curing, end of curing period.
10. 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.
11. Observe preparations for protection from hot weather, cold weather, sun, and rain and preparations for curing.
12. Observations of Concrete Mixing:
- a. Monitor and record amount of water added at Project site.
 - b. Observe minimum and maximum mixing times.
13. Other Inspections:
- a. Grouting under base plates.
 - b. Grouting anchor bolts and reinforcing steel in hardened concrete.
14. Test for Water Soluble Chloride Ion Content in Hardened Concrete:
- a. Test in accordance with procedure described in FHWA Report No. FHWA RD-77-85.
 - b. Make one test for each set of compressive strength test specimens.
 - c. Test may be waived by Architect upon written request from Contractor after review of concrete design mix has been made.

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.

3.12 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. 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 propose materials, methods, and procedures to the Architect for review and approval prior to proceed with structural repairs.

3.13 PROTECTION

A. Protect finished work.

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 03 31 00