



SECTION 03 31 00
STRUCTURAL CONCRETE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. CONTRACTOR shall furnish all labor, tools, and equipment for the construction of reinforced cast-in-place concrete.
- B. This section includes basic finishing and curing methods, accessory control, and expansion and contraction joint devices.

1.02 RELATED SECTIONS

- A. The following is a list of SPECIFICATIONS which may be related to this section:
 - 1. Section 03 11 00, Concrete Forming.
 - 2. Section 03 15 00, Construction Joints.
 - 3. Section 03 15 13, Waterstops.
 - 4. Section 03 21 00, Reinforcing Steel.
 - 5. Section 03 35 00, Concrete Finishing.
 - 6. Section 03 39 00, Concrete Curing.
 - 7. Section 07 92 00, Sealants.
 - 8. Section 32 16 00, Sidewalks, Curbs, and Gutters.

1.03 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. ASTM International (ASTM):
 - a. C33, Standard Specification for Concrete Aggregates.
 - b. C94/C94M, Standard Specification for Ready-Mixed Concrete.
 - c. C150, Standard Specification for Portland cement.
 - d. C260, Standard Specification for Air-entraining Admixtures for Concrete.
 - e. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.



- f. C618, Standard Specification for Coal and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - g. C979, Standard Specification for Pigments for Integrally Colored Concrete.
 - h. C1059, Standard Specification for Latex Agents for Bonding Fresh To Hardened Concrete.
 - i. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
2. American Concrete Institute (ACI):
- a. 211, Standard Practice for Selecting Proportions for Concrete.
 - b. 301, Specifications for Structural Concrete.
 - c. 304, Guide for Measuring, Mixing, Transporting and Placing Concrete.
 - d. 305.1, Specification for Hot Weather Concreting.
 - e. 306.1, Specification for Cold Weather Concreting.
 - f. 309, Standard Practice for Consolidating Concrete.
 - g. 318, Building Code Requirements for Structural Concrete.
 - h. 504, Guide to Joint Sealants.

1.04 SUBMITTALS

- A. Provide product data on the following:
 - 1. Ready-mixed concrete mix designs.
 - 2. Fly ash.
 - 3. Admixtures (such as air-entraining and water-reducing admixtures).
 - 4. Form release agents.
 - 5. Bonding agents.
 - 6. Grout.

1.05 QUALITY ASSURANCE

- A. **Qualifications:** The ready-mixed concrete supplier to CONTRACTOR shall have the capability to produce and deliver concrete, meeting the requirements of the DRAWINGS and SPECIFICATIONS. The supplier shall have a contingency plan for a back-up plant in the event of a mechanical malfunction of one of the primary plant(s).



1.06 DELIVERY, STORAGE, AND HANDLING

- A. The ready-mixed concrete truck driver shall provide the batch ticket to ENGINEER at the time of concrete delivery. The ticket shall summarize the following information legibly in an easily discernible table:
1. Weight in pounds of all materials, excepting the water reducing and air-entraining agents which shall be in ounces.
 2. Cubic yards batched.
 3. The ratio of water to cementitious (W/C) materials ratio.
 4. Temperature of the concrete at the time it was batched.
 5. Time of batching.
 6. Free moisture in the fine and coarse aggregates in percent of weight of aggregate.
 7. Gallons of water that may be added at the site without exceeding the permissible W/C ratio.
 8. Concrete Mix Design Number.

PART 2 PRODUCTS

2.01 MATERIALS

- A. General: Acquire cement and aggregate from the same source for all work.
- B. Cement: Cement shall be Portland cement Type II, unless otherwise indicated on the DRAWINGS.
- C. Aggregate:
1. Fine Aggregate: Fine aggregate shall consist of hard, strong, durable particles complying with the provisions of ASTM C33.
 2. Coarse Aggregate: Coarse aggregate shall conform to the provisions of ASTM C33. Aggregate shall be crushed aggregate or angular screened natural aggregate. Hydraulic - cement aggregate is unacceptable.



- D. **Water:** Water shall be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances that may be deleterious to concrete or steel. Mixing water for prestressed, pretensioned and prestressed post-tensioned concrete or for concrete which will contain aluminum embedments shall not contain deleterious amounts of chloride ion.

- E. **Admixtures:** Admixtures to be used in concrete shall be subject to prior acceptance by ENGINEER. The admixture shall maintain the same composition and performance throughout the WORK as the product used in the concrete proportions established in accordance with ACI 211. Admixtures containing chloride ions shall not be used.

1. **Air Entrainment:**

- a. An air-entraining agent shall be used in all concrete. The agent used shall conform to ASTM C260.

- b. Unless otherwise shown on the DRAWINGS, the amount of air-entraining agent used in each concrete mix shall be such as will affect the entrainment of the percentage of air shown in the following tabulation in the concrete as discharged from the mixer or pumper discharge hose if applicable. Table 1 is applicable for concrete strengths less than five thousand (5,000) psi.

Table 1		
Nominal Max. Aggregate Size (Inch)	Average Air Content (Percent)	
	Severe Exposure	Moderate Exposure
3/8	7-1/2 ± 1-1/2	6 ± 1-1/2
3/4	6 ± 1-1/2	5 ± 1-1/2
1-1/2	5-1/2 ± 1-1/2	4-1/2 ± 1-1/2

- c. The level of exposure shall be determined by ENGINEER.

 - d. When a batch of concrete delivered to the PROJECT does not conform to the minimum specified air content, an air-entraining admixture may be added, one (1) time only for the batch, at CONTRACTOR's option prior to consideration for rejection. After the admixture is added, the concrete shall be remixed for a minimum of twenty (20) revolutions of the mixer drum at mixing speed. The concrete shall then be retested and if found acceptable, may be placed in accordance with the SPECIFICATIONS.
2. **Water Reducing, Set-Controlling Admixture:** CONTRACTOR shall use a "mid-range" water reducing, set controlling admixture, Polyheed 997, or equal. The water-reducing admixture shall be used in all concrete and shall conform to ASTM C494/C494M, specifically Types A, B, C, D, and E.



3. Finely Divided Mineral Admixtures (Fly Ash): Mineral admixtures shall be limited to fly ash conforming to ASTM C618, Class C or Class F. Class C fly ash is not permitted where sulfate resistant cement is required.
- F. Evaporative Retardant: In accordance with Section 03 29 00, Concrete Curing.
- G. Bituminous Coating: Bituminous Coating for aluminum pipes will be in accordance with AASHTO M-190 Type A.
- H. Grout: In accordance with Section 03 60 00, Grouting.
- I. Epoxy Bonding Agent:
 1. Master Builders; Concrese Liquid (LPL).
 2. Master Builders; Concrese Standard Liquid.

2.02 COMPRESSIVE STRENGTH

- A. Concrete compressive strength requirements consist of a minimum strength that must be obtained before various loads of stresses are applied to the concrete and, for concrete designated by strength, a minimum strength at the age of twenty eight (28) days. Unless otherwise shown on the DRAWINGS, the twenty eight (28) day compressive strength of structural concrete shall be a minimum of four thousand five hundred (4,500) psi.
- B. The mix shall be designed for required strengths in accordance with ACI 301. The ratio of water to the sum of concrete plus pozzolan shall not exceed 0.45 by weight for durable, watertight, concrete. The amount of fly ash in the mix shall be between fifteen and twenty percent (15 and 20%) by weight of the total cementitious materials.
- C. Unless otherwise permitted or specified in the DRAWINGS, the concrete shall be proportioned and produced to have a slump not to exceed four (4) inches or less than two and one-half (2-1/2) inches. Concrete not consolidated by internal vibration shall be proportioned to have a slump not to exceed five and one-half (5-1/2) inches or less than four (4) inches.

2.03 SOURCE QUALITY CONTROL

- A. Batching:
 1. Measuring and batching of materials shall be done at a batching plant.
 2. Portland Cement:
 - a. Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete unless the cement is weighed. Bulk cement shall be weighed on scales separate and distinct from the aggregate hopper or hoppers. Batching shall be such that the accuracy of batching shall be plus or minus one percent of the required weight.



3. Water:

- a. Unless water is to be weighed, the water-measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. In lieu of the volume method, CONTRACTOR shall be permitted to use a water-metering device.

4. Aggregates:

- a. Aggregates shall be handled from stockpiles or other sources to the batching plant in such a manner as to secure a uniform grading of the material. Aggregates that have become segregated, or mixed with earth or foreign material, shall not be used. Batching shall be so conducted as to result in the weights of material required for each type aggregate within a tolerance of two percent (2%).
- b. Free water contents of the coarse and fine aggregates shall be continuously tested and concrete mixture adjusted for moisture conditions of the aggregate in order to meet the designated water/cement ratio.

5. Fine Aggregate:

- a. The proportion of fine aggregate shall be between thirty six and forty four percent (36 and 44%) by volume of the total aggregates in the concrete.

B. Mixing:

1. Ready-mixed concrete shall be either “central mixed” or “shrink mixed” concrete as defined in ASTM C94/C94M. “Truck mixed” concrete as defined in ASTM C94/C94M shall not be permitted. Mixing time shall be measured from the time water is added to the mix, or cement contacts the aggregate. All concrete shall be homogeneous and thoroughly mixed, and there shall be no lumps or evidence of undispersed cement. Mixers and agitators, which have an accumulation of hard concrete or mortar, shall not be used. Ready-mixed concrete shall be mixed and transported in accordance with ASTM C94/C94M.
2. The temperature of mixed concrete, immediately before placing shall not be less than fifty degrees Fahrenheit (50°F) or more than ninety degrees Fahrenheit (90°F). Aggregates and water shall be heated or cooled as necessary to produce concrete within these temperature limits. Neither aggregates nor mixing water shall be heated to exceed one hundred fifty degrees Fahrenheit (150°F).
3. The time elapsing from the time water is added to the mix (or the cement comes in contact with aggregate) until the concrete is deposited in place at the site of the WORK shall not exceed sixty (60) minutes when the concrete is hauled in non-agitating trucks, nor more than ninety (90) minutes when hauled in truck mixers or truck agitators.



4. The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first one-quarter (1/4) of the specified mixing time.
 5. Cement shall be charged into the mixer by means that will not result in loss of cement because of the effect of wind, or in accumulation of cement on surfaces of hoppers or in other conditions which reduce or vary the required quantity of cement in the concrete mixture.
- C. Transporting Mixed Concrete; Mixed Concrete or Truck Mixers:
1. Transporting of mixed concrete shall conform to ASTM C94/C94M.
 2. Truck agitators shall be loaded not to exceed the manufacturer's guaranteed capacity. They shall maintain the mixed concrete in a thoroughly mixed and uniform mass during hauling.
 3. No additional mixing water shall be incorporated into the concrete during hauling or after arrival at the delivery point, unless approved by ENGINEER. If additional water is to be incorporated into the concrete at the site, the drum shall be revolved not less than thirty (30) revolutions at mixing speed after the water is added and before discharge is commenced. One (1) addition of water at the site to adjust mix workability is permitted but the maximum water cement ratio shall not be exceeded.
 4. CONTRACTOR shall furnish a water-measuring device in good working condition, mounted on each transit mix truck, for measuring the water added to the mix on the site. All water tanks on transit mix trucks shall be filled prior to being batched and arrive at the construction site one hundred percent (100%) full.
 5. Each load of ready mixed concrete delivered at the job shall be accompanied by the ticket in accordance with Article Delivery, Storage, and Handling.

PART 3 EXECUTION

3.01 PREPARATION

- A. Prior to placing concrete, CONTRACTOR shall remove all debris and thoroughly dampen the surfaces that may be in contact with the concrete to be placed.
- B. CONTRACTOR shall use compressed air from an air compressor to blow out construction debris and dirt at the bottom of members to be placed such as walls, beams, and columns, prior to final placement of forms that may obscure any joint. CONTRACTOR shall demonstrate to ENGINEER that all debris, such as concrete particles, saw dust, loose tie wire, bar tags, tape, trash and dirt, have been thoroughly removed.
- C. All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed shall be cleaned of all such mortar or grout before the surrounding or adjacent concrete is placed.



- D. No concrete shall be placed until all formwork, reinforcement, installation of parts to be embedded, bracing of forms, and preparation of surfaces involved in the placing have been reviewed by ENGINEER.
- E. Immediately before placing concrete, all surfaces upon or against which the concrete is to be placed shall be free from standing water, mud, debris, or loose materials.
- F. No concrete shall be placed when form surfaces that may be in contact with the concrete, reinforcement, embedded items or sub-base is less than thirty two degrees Fahrenheit (32°F). When the mean daily outdoor temperature is less than forty degrees Fahrenheit (40°F), the temperature of the concrete shall be maintained between fifty degrees Fahrenheit (50°F) and seventy degrees Fahrenheit (70°F) for the required curing period. When necessary, arrangements for heating, covering, insulating, or housing the concrete work shall be made in advance of placement and shall be adequate to maintain the required temperature without injury as a result of concentration of heat. Combustion heaters shall not be used during the first twenty four (24) hours unless precautions are taken to prevent exposure of the concrete to exhaust gases which contain carbon dioxide.
- G. Concrete shall not be placed against forms exposed to heating unless the temperature of the forms is first cooled to less than or equal to ninety degrees Fahrenheit ($\leq 90^{\circ}\text{F}$).

3.02 PLACEMENT

- A. Placement shall conform to ACI 301, Chapter 8, ACI 304, ACI 306.1, ACI 305.1, and ACI 309. No concrete shall be placed in water except with the written permission of ENGINEER. The surfaces of absorptive materials against or upon which concrete is to be placed shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete. The concrete shall be placed by equipment that will prevent segregation or loss of ingredients. The stream of concrete shall not be allowed to separate by permitting it to fall freely over rods, spacers or other embedded materials.
- B. Unless otherwise called out in these SPECIFICATIONS or shown on the DRAWINGS, the placement lift depth of concrete in walls shall be limited to two (2) feet or less to minimize surface defects such as air voids that can form on concrete surfaces. Lift depths shall be limited to one (1) foot if, in the opinion of ENGINEER, the quality of the finish is unacceptable at the two- (2-) foot lift depth.
- C. Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement.
- D. Concrete shall not be dropped more than five (5) feet unless confined by closed chutes or pipes. Care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred and strain shall not be placed on the ends of projecting reinforcement.
- E. Where steep slopes are required, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement.
- F. Concrete shall not be pumped through aluminum alloy pipe.



- G. All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete.

3.03 CONSOLIDATION

- A. Concrete vibrators for consolidating concrete shall be two and one-half inch (2-1/2") diameter "high cycle" vibrators with a frequency under load of eight thousand (8,000) to ten thousand four hundred (10,400) vibrations per minute (vpm). Concrete vibrators of lesser capacity are unacceptable for use in any part of the construction. CONTRACTOR shall have at least one standby concrete vibrator ready for use for every two (2) concrete vibrators in use during a concrete placement.
- B. All concrete shall be thoroughly consolidated with internal vibrators as recommended in ACI 309 immediately after deposition. The concrete shall be thoroughly worked around the reinforcing steel, around embedded items and into corners of forms. Vibration shall be supplemented by spading, rodding, or forking to eliminate all honeycomb and voids around embedded items.
- C. The vibrator shall be inserted vertically, allowing it to penetrate rapidly to the bottom of the lift and at least six (6) inches into the previous lift. The vibrator shall be held at the bottom of lift for five to fifteen (5 - 15) seconds. The vibrator shall be pulled up at a rate of about three (3) inches per second.
- D. The vibrator shall be inserted so that the fields of action overlap. The field of action is approximately eight (8) times the vibrator's head diameter. Thus for a two and one-half (2-1/2) inch diameter vibrator, the spacing of each insertion shall be approximately twenty (20) inches.
- E. Vibration shall be stopped when the concrete surface takes a sheen and large air bubbles no longer escape.
- F. Do not use a vibrator to move concrete horizontally.

3.04 OPENINGS AND INSERTS

- A. Pipe sleeves, inserts for pipe connections, anchors, and forms for pipe holes shall be accurately placed and securely fastened to the forms in such a manner that the placing of concrete shall not alter their alignment or location. In the event that openings are inadvertently omitted or improperly placed, ENGINEER may require the concrete to be cored at the proper location. Filling of improperly placed openings shall be done with expansive grout or dry pack or mortar applied with an accepted epoxy adhesive. The surfaces of the opening shall be roughened prior to filling.

3.05 EMBEDDED ITEMS

- A. At the time of concrete placement, embedded items shall be clean and free from mud, oil, and other coatings that may adversely affect bonding capacity. Aluminum embedments shall be coated with a bituminous material to prevent electrolytic action between the embedded item and reinforcing steel that results in concrete deterioration. Embedment items shall be accurately placed and securely fastened to the forms in such a manner that the placing of concrete shall not alter their alignment or location. Contact between embedded items and reinforcing steel or tendon ducts is unacceptable and is not permitted.



3.06 CONSTRUCTION JOINTS

- A. The location of all construction joints shall be subject to the acceptance of ENGINEER. The surface of all construction joints shall be thoroughly cleaned and all laitance and standing water removed. Clean aggregate shall be exposed by abrasive blast cleaning. Wire brushing and air water jets may be used while concrete is fresh provided results are equal to abrasive blast cleaning. Construction joints shall be keyed at right angle to the direction of shear. Except where otherwise shown on the DRAWINGS, keyways shall be at least one and one-half (1-1/2) inch in depth over at least twenty five percent (25%) of the area of the section.

3.07 EVAPORATIVE RETARDANT

- A. The use of an evaporative retardant is required to assist in proper placement of concrete in accordance with Section 03 29 00, Concrete Curing. Apply two (2) times; after screeding and after the first floating operation. The retardant should be applied at a rate of one (1) gallon of sprayable solution per two hundred to four hundred (200 - 400) square feet by spraying with an industrial type sprayer. If the nozzle of the sprayer becomes plugged, CONTRACTOR shall clean, or replace, the nozzle. Under no circumstances shall the retardant be used except by spraying a mist with a nozzle. The retardant shall be applied in strict conformance with the manufacturer's recommendations and precautions. In no case shall the retardant be used as a finishing agent. The use of an evaporative retardant requires review and approval by ENGINEER.

3.08 FIELD QUALITY CONTROL

- A. CONTRACTOR shall assist OWNER or the concrete testing consultant as requested during the performance of quality control testing. When concrete is placed using a concrete pumper, concrete for testing will be taken from the pumper discharge hose.

END OF SECTION