FOR PROJECTS INITIATED
AFTER MAY 1, 2014
REVISION 9

# ITEM 421

# STRUCTURAL CONCRETE

421.1 Description. This Item shall govern for the materials used; for the storing, measuring and handling of materials and for the proportioning and mixing of concrete for bridges, culverts, signal pole foundation, other concrete structures, and incidental construction. Concrete shall meet the requirements of:

A. ACI 318 "Building Code Requirements for Reinforced Concrete".

B. The ASTM Standards.

C. ACI "Manual of Concrete Practice".

421.2 Materials. Concrete shall be composed of Portland cement, coarse and fine aggregate, water and chemical admixtures as outlined below:

A. Portland cement shall meet the requirements of ASTM C150 "Specification for Portland Cement". Unless otherwise permitted or required, cement shall be Type I or Type III.

B. Mixing water for concrete shall conform to the requirements for water specified in ASTM C94 "Specification for Ready-Mixed Concrete".

C. Chemical admixtures shall conform to the following specifications:

1. Air-entraining admixtures shall conform to the requirements of ASTM C260 "Specification for Air-Entraining Admixtures for Concrete".

2. Chemical admixtures shall conform to the following requirements of ASTM C494 "Specification for Chemical Admixtures for Concrete":

a. Water Reducing Admixtures: ASTM C494, Type A
b. Retarding Admixtures: ASTM C494, Type B
c. Accelerating Admixtures (Non-Chloride): ASTM C494, Type C
d. Water Reducing Retarding Admixtures: ASTM C494, Type D
e. High Range Water-Reducing Admixtures: ASTM C494, Type F and G

Admixtures containing calcium chloride are prohibited in any type of structural concrete.

Structural concrete for Bridge Decks: Accelerating admixtures and High Range Water-Reducing admixtures are prohibited.

3. High early strength concrete may be produced from either Type I or Type III Portland cement. If Type I cement is used in lieu of Type III, the Contractor shall use an accelerating admixture conforming to ASTM C494, Type C. The accelerator shall be used in accordance with that manufacturer's recommendations.

D. Aggregates for normal weight concrete shall conform to the requirements of ASTM C33 "Specification for Concrete Aggregates".

Coarse aggregates shall consist of durable particles of gravel, crushed stone, or combinations thereof; free from frozen material or injurious amounts of salt, alkali, vegetable matter, or other objectionable material. It shall not contain more than 0.25 percent, by weight, of clay lumps, not more than 1.0 percent, by weight, of shale not more than 5 percent, by weight, of laminated and/or friable particles. It shall have a wear of not more than 35 percent when tested in accordance with ASTM C131, "The Los Angeles Abrasion Test".

Coarse aggregate shall be subjected to five cycles of both the sodium sulfate and the magnesium sulfate soundness tests. Coarse aggregate which has a loss greater than 12 percent with sodium sulfate and/or 18 percent with magnesium sulfate shall not be accepted.

Gradation of coarse aggregate shall conform to the grading requirements shown in Table 1.

TABLE 1 - Coarse Aggregate Gradation

| Nominal Size | Percent by Weight, Retained on Square Sieve | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2" | 1-1/2" | 1" | 3/4" | 3/8" | No. 4 | No. 8 |
| 1-1/2" | 0 | 0-5 | | 30-65 | 70-90 | 95-100 | |
| 3/4" | 0 | 0 | 0 | 0-10 | 45-80 | 90-100 | 95-100 |

The loss by decantation of coarse aggregate shall be from 0 to 1%.

Fine aggregate shall consist of clean, hard, durable and uncoated particles of natural or manufactured sand or a combination thereof, with or without a mineral filler. It shall be free from frozen material or injurious amounts of salt, alkali, vegetable matter or other objectionable material and it shall not contain more than 0.5

percent by weight of clay lumps. When subjected to the color test for organic impurities, it shall not show a color darker than standard. The fine aggregate shall produce a mortar having a tensile strength equal to or greater than that of Ottawa sand mortar.

Mineral filler shall consist of stone dust, clean crushed sand or other approved inert material.

Gradation of fine aggregate shall conform to the grading requirements shown in Table 2.

TABLE 2 - Fine Aggregate Gradation

| Percent, By Weight Retained on Square Sieve | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3/8" | No. 4 | No. 8 | No. 16 | No. 30 | No. 50 | No. 100 | No. 200 |
| 0 | 0 - 5 | 0 - 20 | 15 - 50 | 35 - 75 | 65 - 90 | 90 - 100 | 97 - 100 |

Fine aggregate shall be subjected to the Sand Equivalent Test. The sand equivalent shall be not less than 80.

The fineness modulus for fine aggregate shall be between 2.30 and 3.10. The fineness modulus will be determined by adding the percentages, by weight, retained on the following sieves, and dividing by 100; Numbers 4, 8, 16, 30, 50 and 100. The fine aggregate shall have not more than 45% passing any sieve and retained on the next consecutive sieve of those shown in Table 2.

421.3 Storage of Materials. Cement shall be stored in well ventilated weathertight buildings, bins, or silos which shall exclude moisture and contaminants.

Aggregate stockpiles shall be arranged and used in such a manner as to avoid contamination, with other materials or with other sizes of like aggregates. To ensure that this condition is met, any test for determining conformance to requirements for cleanliness and grading shall be performed on samples secured in accordance with ASTM D75. Frozen or partially frozen aggregates shall not be used. Unless otherwise authorized by the Engineer, all aggregate shall be stockpiled at least 24 hours prior to use, to reduce free moisture content.

Chemical admixtures shall be stored in such a manner as to avoid contamination, evaporation, or damage. For those used in the form of suspensions or non-stable solutions, agitating equipment shall be provided to assure thorough distribution of the ingredients. Liquid admixtures shall be protected from freezing and from temperature changes which would adversely affect their characteristics.

421.4 Proportioning of Concrete. Concrete for all parts of the work shall be of the specified quality, capable of being placed without excessive

segregation and, when hardened, of developing all characteristics required by this Item and the contract documents.

The specified compressive or flexural strength of the concrete, for each portion of the structure, shall be as designated in the contract documents.

Strength requirements shall be based on the 28 day and 7 day compressive strength, respectively.

421.5 Concrete Classification. Concrete shall be classified as shown in Table 3.

TABLE 3 - Concrete Classification

| | | | | | Maximum Allowable Water-Cement ratio, by weight (lb. of $H_2O$/lb. of cement) | |
|---|---|---|---|---|---|---|
| Class | Nominal Coarse Aggregate | Cement Sacks Per C.Y. | Minimum 28-day strength f'c | Minimum 7-day strength f'c | Non-Air Entr. Conc. | Air Entr. Conc. |
| $A_1$ | 1-1/2" | 7 | 4,000 psi | 2,800 psi | 0.46 | 0.46 |
| *$A_2$ | 3/4" | 7 | 4,000 psi | 2,800 psi | 0.52 | 0.46 |
| $B_1$ | 1-1/2" | 6 | 3,500 psi | 2,400 psi | 0.53 | 0.49 |
| *$B_2$ | 3/4" | 6 | 3,500 psi | 2,400 psi | 0.60 | 0.54 |
| $C_1$ | 1-1/2" | 5.5 | 3,000 psi | 2,100 psi | 0.58 | 0.52 |
| *$C_2$ | 3/4" | 5.5 | 3,000 psi | 2,100 psi | 0.66 | 0.59 |
| $D_1$ | 1-1/2" | 5 | 2,500 psi | 1,750 psi | 0.63 | 0.59 |
| *$D_2$ | 3/4" | 5 | 2,500 psi | 1,750 psi | 0.72 | 0.65 |

* Other nominal maximum aggregate sizes will be allowed, based on the thickness of section or spacing of reinforcing bars, or other criteria, as approved by the Design Engineer.

421.6 Selection of Proportions. Proportions of materials for concrete shall be established to provide:

A. Workability and consistency to permit concrete to be worked readily into forms and around reinforcement under conditions of placement to be employed without segregation or excessive bleeding.

B. Strength requirements in accordance with Table 3.

C. Resistance to special exposure as required by the Engineer and as specified in the contract documents in any Special Provisions.

All classes of concrete shall have a 3 inch slump as determined in accordance with ASTM C143 with an allowable tolerance of ± 1 inch. The average slump for all classes of concrete may range to the wet side of the tolerance. If High Range Water-Reducing admixture is used, maximum acceptable placement slump shall be 9 inches.

The allowable air content for moderate exposures is:

| | |
|---|---|
| 1-1/2" aggregate (No. 2) | 2.5 - 5.0 percent |
| 3/4" aggregate (No. 5) | 3.0 - 5.0 percent |

421.7 Evaluation and Acceptance of Concrete. Samples for strength tests shall be taken in accordance with ASTM C172 "Method of Sampling Freshly Mixed Concrete".

Cylinders for strength tests shall be molded and laboratory cured in accordance with ASTM C31 "Method of Making and Curing Concrete Test Specimens in the Field", for 7 and 28 day testing. Specimens shall be tested in accordance with ASTM C39 "Test Method for Compressive Strength of Cylindrical Concrete Specimens". Two cylinders shall be molded for the 28 day test and two cylinders for the 7 day test. For structural concrete, one set of cylinders shall be cast for a pour of 50 yards.

The strength level of an individual class of concrete shall be considered satisfactory, if both of the following requirements are met:

A. Average of all sets of three consecutive strength tests equal to or exceed specified f'c.

B. For concrete structures, no individual strength test (average of two cylinders falls below f'c by more than 500 psi.)

421.8 Production of Concrete. Ready mixed concrete shall be batched, mixed and transported in accordance with ASTM C94 "Specification for Ready-Mixed Concrete".

The concrete shall be mixed in the quantities required for immediate use, and any concrete which has developed initial set or which is not in place within 1-1/2 hours after the initial water has been added, shall not be used.

No concrete shall be mixed while the air temperature is at or below 35ºF. The temperature of the concrete shall at no time fall below 60ºF or exceed 90ºF. When the concrete reaches a temperature of 85ºF, retarders shall be introduced into the mixture.

Chemical admixtures shall be charged into the mixer as solutions and shall be measured by means of an approved mechanical dispensing device. The liquid shall be considered as part of the mixing water. Admixtures that cannot be added in solution may be weighed or may be measured by volume if so recommended by the manufacturer.

If two or more admixtures are used in the concrete, they shall be added separately to avoid possible interaction that may interfere with the efficiency of either admixture or adversely affect the concrete.

When concrete arrives at the project with a slump below that suitable for placing, as indicated by the specifications, water may be added only if the maximum permissible water-cement ratio and maximum slump is not exceeded. The water shall be incorporated by additional mixing equal to at least half of the total mixing required.

421.9 Placing of Concrete. Concrete shall not be placed into any formwork, until that formwork has been inspected by the Engineer. It is the Contractor's responsibility to determine if the formwork will support the load and that all of the reinforcement is in place.

Concrete shall be conveyed from mixer to place of final deposit by methods that will prevent separation or loss of materials and without interruptions sufficient to permit loss of plasticity between successive increments.

Concrete shall be deposited as near as practicable in its final position to avoid segregation due to rehandling or flowing. Depositing large quantities at one point in the forms and running and/or working it along the forms will not be permitted. Pumped concrete shall not be dropped more than 3 feet from the bottom of the "elephant trunk/boot".

Concrete that has partially hardened or been contaminated by foreign materials shall not be deposited in the structure.

In depositing the concrete, care shall be taken to entirely fill the form, and to consolidate the concrete by continuous vibratory means. The concrete shall be placed in forms designed to support the load and not bulge, distort the forms, or disturb their alignment.

Any porous section may be removed at the expense of the Contractor.

Sufficient placing capacity, as well as mixing and transporting capacity, should be provided so that the concrete can be kept plastic and free of cold joints while it is being placed. It should be placed in horizontal layers not exceeding 2 feet (60 centimeters) in depth, avoiding inclined layers and cold joints. For monolithic construction each concrete layer shall be placed before an initial set has taken place in the previous layers, and layers shall be sufficiently shallow to permit knitting the two together by proper means. Special care shall be taken in filling the forms, to

thoroughly work the concrete under and around the reinforcement, embedded fixtures and into corners of forms.

After concreting is started, it shall be carried on as a continuous operation until complete as defined by its boundaries or predetermined joints. When construction joints are required, joints shall be made as specified in the contract documents.
After the concrete has taken its initial set, care shall be exercised to prevent walking on the concrete, to avoid jarring the forms or knocking or straining projecting reinforcement.

421.10 Concreting in Cold Weather. No concrete shall be placed when the atmospheric temperature is below 35°F unless permission to do so is granted in writing by the Engineer. When such permission is given, the requirements of ACI 306R "Cold Weather Concreting", shall govern. The Contractor shall assume all risk connected with placing concrete during freezing weather. The Engineer's permission in no way relieves the Contractor of proper and satisfactory quality concrete placement.

421.11 Concreting in Hot Weather. Hot weather is defined as any combination of high air temperature, low relative humidity, and wind velocity tending to impair the quality of fresh or hardened concrete or otherwise resulting in abnormal properties.

Concrete placement in hot weather should be performed in a period of time so as to reduce water demand and slump loss. This period of time should not exceed 1-1/2 hours after cement has been mixed in the batch.

Small increments of retempering water may be added, with Engineer's approval, to mixed batches to obtain the mix design slump. However, the production of concrete of excessive slump or adding water in excess of the mix design to compensate for slump loss resulting from delays in delivery or placing shall be prohibited.

The Contractor shall follow all requirements of ACI 305R "Hot Weather Concreting" for placing concrete in hot weather and assume all risk involved in its placing.

421.12 Curing Concrete. Concrete (other than high early strength) shall be maintained above 50ºF, protected from the sun, and kept in a moist condition for at least the first 7 days after placement. High early strength concrete shall be maintained above 50ºF, protected from the sun, and in a moist condition for at least the first 3 days.

Accelerated curing methods are not allowed.

Concrete shall be cured from loss of moisture for not less than 72 hours for pavement and not less than 7 days for structures from initiation of the curing process. Curing methods acceptable to Harris County are:

A. Sealing Materials: White, clear, or for cold weather, black plastic shall be used to completely cover and seal structure and/or pavement from moisture loss. The plastic material shall be no less than 0.004 inches (0.10 millimeters) in thickness. Two thicknesses shall be required on all finished concrete during cold weather (50° F and below). Precautions shall be taken to prevent traffic on and tears in plastic cover. All tears shall be remedied immediately to prevent moisture loss and deleterious material introduction. Plastic shall conform to ASTM C171 "Sheet Materials for Curing Concrete".

B. Liquid Membrane: Placed concrete not cured by plastic sealing method may be cured using liquid membrane curing. See the Item 526 "Membrane Curing". Abutment caps, bridge slabs, bridge sidewalks, bridge rails, retaining walls, culvert, and culvert headwalls shall not be cured using curing compounds.

C. Additional Curing Methods: Methods not listed will be noted in a Special Provision to this Item, by the Engineer and referenced to ACI 308 "Curing Concrete".

421.13 Inspection and Testing. Concrete materials and operations will be tested and inspected as the work progresses. Failure to detect any defective work or material shall not in any way prevent later rejection when such defect is discovered nor shall it obligate the Engineer for final acceptance.

421.14 Responsibilities and Duties of the Contractor. The Contractor shall:

A. Submit the proposed concrete mix design furnished by the supplier.

B . Provide other testing services needed or required by the Contractor.

C. Facilitate testing and inspection, by furnishing any necessary labor to assist the designated Testing Laboratory in obtaining and handling samples at the project or other sources of materials.

D. Advise the Testing Laboratory’s representative sufficiently in advance of operations to allow for completion of quality tests and for the assignment of personnel.

E. Submit copies of mill test reports for shipments of cement, reinforcing steel and prestressing tendons to the Engineer when required.

421.15 Fly Ash. The percent amount of fly ash used in the mix design for structural concrete, shall be based on the Mix Design Options depicted in the Texas Department of Transportation’s “Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges” Latest Edition, Specification Item 421 “Hydraulic Cement Concrete”, and as approved by the Design Engineer.

421.16 Quality Assurance. The Testing Laboratory's representative will sample and test the concrete mixtures being used for the specific designations in accordance with the requirements given for that designation.

For structural concrete used in all except prestressed structures, the Testing Laboratory's representative will mold four cylinders for each set of test specimens, from each batch sampled. The cylinders will be tested in accordance with ASTM C39 at 28 days.

The average strength for the set will be determined by use of the average of the two cylinders tested.

For structural concrete used in prestressed concrete structures, the manufacturer shall supply cylinder molds to the Testing Laboratory's representative to cast early release test cylinders. These cylinders shall be cast and cured along side the precast/prestressed unit and tested by the manufacturer. The compressive strength test shall be performed in accordance with ASTM C39 and witnessed by the Testing Laboratory's representative to insure that the concrete meets the minimum requirements of 4000 psi compressive strength prior to stress transfer. Four additional test cylinders shall also be cast and cured in accordance with ASTM C31 for each lot of precast concrete. Two cylinders shall be tested 7 days. The remaining two cylinders shall be tested at 28 days to insure that the minimum 28 day compressive strength is obtained.

421.17 Measurement. The method of measurement for structural concrete shall be as shown in the table below:

| Structural Component | Method of Measurement |
|---|---|
| Columns | Cubic Yards |
| Caps | Cubic Yards |
| Wingwalls | Cubic Yards |
| Headwalls | Cubic Yards |
| Abutments | Cubic Yards |
| Bridge Decks | Square Yards |
| Retaining Walls | Cubic Yards |
| Bridge Sidewalks | Square Yards |
| Approach Slabs | Square Yards |
| Parapet Walls | Cubic Yards |
| Spread Footings | Cubic Yards |
| Concrete Bridge Medians | Cubic Yards |
| Signal Pole Foundations | Vertical Foot by Diameter |

Any structural components not listed above shall be measured by the cubic yard.

421.18 Payment. Structural concrete shall be paid for at the contract unit price bid based on the measurement shown above.

There are line code(s), description(s), and unit(s) for this Item.
NOTE : This Item requires other Standard Specifications

Item 526 “Membrane Curing”

END OF ITEM 421