

**DIVISION 03**

**CONCRETE**

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## **SECTION 03100 CONCRETE FORMWORK**

### **1.00 GENERAL**

#### **1.01 SCOPE**

- A. Furnish all materials, labor, equipment , plant , tools, required to complete:
  - all cast in place concrete form work.
- B. All work shall be done in accordance with the minimum requirements of the AMERICAN CONCRETE INSTITUTE CODE FOR REINFORCED CONCRETE ACI 381 except as modified herein.
- C. Refer to the General Conditions for all pertinent provisions.

#### **1.02 SUBMITTALS**

Shop drawings of formwork when required by the Architect shall be submitted for approval before fabrication and erection of such formwork.

#### **1.03 APPROVAL**

All form materials are subject to approval before fabrication of formworks.

#### **1.04 CLEANING AND OILING OF FORMS**

- A. Before placing the concrete, clean the contact surfaces of the forms of encrustation of mortar, grout, or other foreign material, and coat with standard form oil that can effectively prevent sticking and staining of the concrete surfaces.

#### **1.05 PROTECTION**

- A. Provide adequately braced forms that will produce correctly aligned concrete, able to meet the specific weights and side pressure of newly placed concrete.
- B. Choose form fittings that are adequate to the purpose.
- C. Exercise care in the choice of surface forms and form fittings that will be in contact with concrete.

### **2.00 PRODUCTS**

Refer to Section 01020 Summary of Materials and Finishes.

### **3.00 EXECUTION**

#### **3.01 PREPARATION**

- A. Check all forms to conform to the shape, lines and dimensions of members as called for in the plans.
- B. Check all formwork for plumbness and correct alignment.
- C. Provide openings in column forms for cleaning and inspection preferably at lowest points of pour lifts.
- D. Provide camber for cantilever and long spans or as indicated in construction notes.
- E. Coat all forms with Nox-crete form oil before reinforcement is placed. Remove all surplus oil on form surfaces.

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### 3.02 FORM AND SHORING

#### A. Removal

1. Remove forms only upon approval of the Engineer in such manner that will prevent damage to the concrete and at such time as to insure the complete safety of the structure. In no case shall the supporting forms and shorings be removed until the members have attained sufficient strength to support their weight and load thereon.
2. Exercise due care while stripping forms and protect corners subsequently against chipping or other damage by approved means.
3. Any repairs of surface imperfections shall be formed at once and curing shall be started as soon as the surface is sufficiently hard to permit it without further damage.
4. The results of suitable control tests shall be used as evidence that the concrete has attained sufficient strength to permit removal of shorings and supporting forms. Cylinders required for control tests shall be made in addition to those required by this Specification.
5. The minimum time period for removal of forms shall govern where it exceeds the minimum specified curing period. Where the formwork for one element supports the framework for another element, the greater time period shall apply to both elements. Forms shall not be removed before the expiration of the minimum time specified below

<i>Element</i>		<i>Time Period (Days Min.)</i>
Walls, columns, sides of beams and girders, and slabs on grade		1
Pan joist forms (side only):		
30 inches wide more or less		3
Over 30 inches wide		4
Where design live load is:	less than dead load	greater than dead load
For Arch center :	14	7
Joist, beam, or girder soffits:		
Under 10 feet	7	4
10 feet to 20 feet	14	7
Over 20 feet	21	14
For one way floor slabs when clear span between structural supports		
Under 10 feet	4	3
10 feet to 20 feet	7	4
Over 20 feet	10	7

### 3.03 SUPPORT

Sufficient shoring members to support dead loads plus construction loads on beams and slabs shall be provided for a period of eight (8) days in addition to the seven (7) days specified thereto. The time for removal of forms for structures not included thereto shall be as directed by the Engineer. Concrete work shall be protected from damage during construction.

### 3.04 TOLERANCE LIMITS

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- A. Set and maintain concrete forms so as to insure completed work within the following tolerance limits.
1. Variation from the plumb
    - a. In the lines and surfaced of columns, piers, walls and rises:  
In 3.00 m (10').....6 mm (1/4")  
In any storey or 6.00 m (20') max.....10 mm (3/8")
    - b. For exposed corner columns, control joints, grooves and other conspicuous lines: In any way 6.00 m (20') max.....6 mm (1/4")  
In 12.00 m (40') or more.....10 mm (3/8")
  2. Variation from the level or from the grades indicated on the drawings:
    - a. In floors (below removal of forms), ceiling beams, soffits and rises.  
In 3.00 m (10').....6 mm (1/4")  
In any way or 6.00 m (20') max.....10 mm (3/8")  
In 12.00 m (40') or more.....10 mm (3/8")
    - b. For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines:  
In any way of 6.00 m (20') max.....6 mm (1/4")  
In 12.00 m (40') or more.....10 mm (3/8")
  3. Variation of the linear building lines from the established position in plan and related position columns, walls and partitions:  
In any way or 6.00 m (20') max.....6 mm (1/4")  
In 12.00 m (40') or more.....25 mm (1")
  4. Variation in the sizes and location of sleeves, floor openings and in thickness of slabs and wall.  
Openings.....6 mm (1/4")
  5. Variation in cross-sectional dimensions of columns and beams and in thickness of slabs and walls:  
Minus.....6 mm (1/4")  
Plus.....12 mm (1/2")
  6. Footings
    - a. Variation of dimensions in Plan  
Minus.....12 mm (1/2")  
Plus.....50 mm (2")  
(applies to concrete only and not to reinforcing bars and dowels).
    - b. Misplacements of eccentricity, 5% of specified thickness.
  7. Variation in steps:
    - a. In a flight of steps:  
Rise.....3 mm (1/8")  
Tread.....6 mm (1/4")
    - b. In consecutive steps:  
Rise.....2 mm (1/16")  
Tread.....3 mm (1/8")

*END OF SECTION 03100*

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## **SECTION 03200 CONCRETE REINFORCEMENT**

### **1.00 GENERAL**

#### **1.01 SCOPE**

- A. Furnish all materials, labor, equipment, plant, tools, required to complete:
- steel reinforcing bars
  - welded wire fabric
  - bar supports and dowels
  - reinforcement accessories, including all wire ties, chairs, spacers, supports, and other necessary devices.
- B. All pertinent provisions of the General Conditions form part of this section.

#### **1.02 SUBMITTALS**

Shop drawings of each reinforcing steel detail and placement drawings shall be submitted for approval in accordance with the requirements of the GENERAL CONDITIONS. Any material fabricated before final approval of the shop drawings will be done at Contractor's risk, but no material shall be placed until shop drawings have final approval. Shop drawings shall be in accordance with the "Manual of Standard Practice for Detailing Reinforced Concrete Structures" (ACI 315).

#### **1.03 PROTECTION AND STORAGE**

Protect steel reinforcement adequately from rusting. Store reinforcing steel on supports, above ground / floor level. Store undercover. Keep covered with tarpaulins, if required, due to a delay in use.

#### **1.04 TESTING**

Tests shall conform to ASTM Designations of specified materials. Samples for testing shall be provided by the Contractor without additional costs to the Owner. Expenses for testing shall be borne by the Contractor. Copies of the results shall be furnished to the Owner and the Architect promptly.

#### **1.05 MEASUREMENT AND PAYMENT**

For deduction or addition in the contract sum due to deletion or extra work involved, the steel reinforcement shall be measured by weight either in kilograms or in tons. The Contractor shall be paid based on the steel weight as per unit prices submitted on the proposal form. Steel bars that are not installed shall not be paid by the Owner.

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## **2.00 PRODUCTS**

Refer to Section 01020 Summary of Materials and Finishes.

## **3.00 EXECUTION**

### **3.01 PREPARATION**

- A. Before placing reinforcement and before pouring of concrete, remove all loose rust, mill scale, oil, or other adhering materials which tend to reduce or destroy bond between concrete and reinforcement.
- B. Cutting and Bending:
  - 1. Reinforcing steel shall be accurately cut and bent in accordance with the approved detailed reinforcement drawings.
  - 2. Reinforcing steel shall not be straightened or re-bent in a manner that will injure the material. Bars with kinks or with bends not shown on the approved detailed reinforcement drawings or with cracks or splits on the bends shall not be used.
  - 3. All bars shall be bent cold. Bends for stirrups and ties shall be made around pins with a diameter of at least twice the thickness of the bars; for bars 25 mm (1") and smaller, six (6) times the thickness; for larger bars, eight (8) times the thickness.
  - 4. If Contractor elects to have reinforcing steel cut and bent off the Site, he shall provide, maintain and operate a small cutting and bending shop on the Site and maintain a representative stock of steel.
  - 5. This provision is to take care of minor revisions and additions in an expeditious manner.

### **3.02 PLACING REINFORCEMENT**

- A. Metal Reinforcement
  - 1. Reinforcing steel shall be accurately placed in accordance with approved detailed reinforcement drawings and shall be adequately secured against displacement by using specified tie wires or approved clips at all intersections. Refer to the Engineer in case of doubt in placing of steel.
  - 2. Reinforcing bars shall be accurately placed and adequately secured with concrete metal wires, metal chair spacer ties or other accessories.
  - 3. Wire mesh reinforcement where shown in slabs shall be secured in position by spacer bars and chairs. Spacer bars shall be lapped not less than 125 mm (5"). In slabs on ground, pre-cast concrete blocks may be substituted for chairs.
  - 4. Reinforcing steel shall be supported by concrete or metal supports, spacers, or metal hangers, except at surfaces exposed to the ground or to the weather, where supports shall be concrete.
  - 5. Wooden support and wooden spreaders shall not be used. At surfaces where an attractive appearance is paramount, the support shall be of a type which shall not cause subsequent staining or marring of the exposed surface.

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6. After it has been installed, reinforcing steel shall be inspected by the Engineer for compliance with requirements as to size, shape, length, splicing, position and number.
- B. Bar Spacing  
Spacing of bars shall be done in accordance with the ACI-Building Code or as follows:
  1. Clear distance between parallel bars shall be one and one-half (1-1/2) times the diameter of the bars.
  2. Clear distance shall not be less than 1-1/3 times the maximum size of aggregates, nor less than 25 mm (1").
  3. Where bars are used in two or more layers, the bars in the upper layers shall be placed directly above those in the lower layers at a clear distance of not less than 25 mm (1").

### 3.03 OFFSET AND SPLICE IN REINFORCEMENT

- A. Splices
  1. Generally, avoid splices in slabs, beams and girders at points of maximum stress. Splices may be allowed only upon written approval of splice details by the Architect / Engineer or as shown or noted in the Plans.
  2. Splice in adjacent bars shall be staggered a minimum distance of forty (40) bar diameters.
- B. Offsets  
Where changes in cross section of columns occur, longitudinal bars shall be offset in a region where lateral support is afforded. Where offset, the slope of the included portion shall not be more than one on six (1:6) and in case of tied columns, the ties shall be spaced 75 mm (3") on center for a distance of 300 mm (1') below and above the point of offset.

*END OF SECTION 03200*

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## **SECTION 03300 CAST-IN-PLACE CONCRETE**

### **1.00 GENERAL**

#### **1.01 SCOPE**

- A. Furnish all materials, labor, equipment, plant, tools, required to complete:
  - proportioning
  - mixing
  - placement
  - curing and
  - finishing of concrete
- B. All pertinent provisions of the General Conditions form part of this Section.

#### **1.02 REFERENCE STANDARDS**

The latest edition of following standards shall form part of this specification:

- A. ACI American Concrete Institute
- B. 211.01- 85 Standard Practice for Selecting Proportions for Normal and Heavyweight Concrete
- C. 301 - 84(R88) Concrete, Structural for Building
- D. 309R-87 Standard Practice for Consolidation of Concrete
- E. 318 - 86 Building Code Requirements for Reinforced Concrete
- F. AASHTO American Association of State Highway and Transport Officials
- G. M173-84 Concrete Joint Sealer, Hot-Poured Elastic Type Performed Expansion Joint Filler for Concrete
- H. ASTM American Society for Testing and Materials
- I. C33-86 Concrete Aggregates
- J. C31-88 Standard Practice for Making, Curing Concrete Test Specimen in the Field
- K. C39-86 Compressive Strength of Cylindrical Concrete Specimen
- L. C42-87 Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
- M. C94-86 Standard Specification for Ready-Mixed Concrete
- N. C143-78 Standard Test Method for Slump of Portland Cement Concrete
- O. C150-86 Portland Cement, Specification for
- P. C309-81 Liquid-Membrane Forming Compounds for Curing Concrete
- Q. C494-86 Chemical Admixtures

#### **1.03 REQUIREMENTS**

Full coordination shall be given other trades to install embedded items. Provisions shall be made for setting items not placed in the forms. Before concrete is placed embedded items shall have been inspected, and test for concrete aggregates and other materials shall have been done.

#### **1.04 PROTECTION & STORAGE**

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- A. Cement :
  - 1. Store cement in bags in suitable dry, water tight, properly ventilated weatherproof structure;
  - 2. Elevate floors above the ground to sufficiently prevent the absorption of moisture.
  - 3. Stock bags close together to reduce circulation of air but shall not be stocked against walls.
  - 4. Storage shall permit easy access for inspection and identification of each shipment.
  - 5. Cement that has been in storage for so long that there may be doubt of each quality shall be tested by standard mortar test to determine its suitability for use, and shall not be used without approval of the Engineer.
- B. Aggregates :
  - 1. Store in am manner as to prevent the inclusion of foreign matter.
  - 2. Aggregates of different sizes shall be stored in separate piles
  - 3. Maintain storage piles in a manner that will afford good drainage.
  - 4. Stock piles of coarse aggregate shall be built in horizontal layers not exceeding 1200 mm in depth to avoid segregation. Should the coarse aggregate become segregated, it shall be remixed to conform to the grading requirements given hereinbefore.
- C. Admixtures – store to prevent deterioration or intrusion of foreign matters.

## **1.02 SUBMITTALS**

- A. Concrete Mix Design
- B. Samples  
Submit samples of cement and aggregates proposed for exposed architectural concrete work for approval, giving names, sources and descriptions of the material.
- C. Reports  
Submit 5 copies of mix design and test results.
- D. Notification  
Submit schedule of pours and location at least 7 days prior to date of pouring for approval.

## **1.04 MEASUREMENT AND PAYMENT**

For deduction or addition on the contract sum due to deletion or extra work involved, measure cast-in-place concrete in cubic meter and base payment on the actual poured volume using the unit prices on the proposal form.

## **1.05 DESIGN STRENGTH OF CONCRETE**

All strengths of concrete shall be as indicated on the Structural Design Criteria / Construction Notes.

## **2.00 PRODUCTS**

### **2.01 MATERIALS**

Refer to Section 01020 Summary of Materials and Finishes.

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## 2.02 CONCRETE PROPORTIONS AND CONSISTENCY

### A. Cement and Aggregate

Make proportions so as to produce a concrete mixture which will work readily into corners and angles of the forms and around reinforcement with the method of placing materials to avoid segregation of accumulation of excess free water on the surface.

### B. Measurement

1. Measure concrete materials such that the proportions can be accurately controlled and easily checked at any time during work.
2. Conform to measurement of materials for ready mixed concrete to STANDARD SPECIFICATIONS FOR READY MIXED CONCRETE. ASTM Designation C-94, where applicable.
3. Never exceed the water content by 6 U.S. gallons per bag of cement for all portions in the structure. Allow job mix adjustment of water content only on permission of the Architect / Engineer provided that cement is also added to keep the original water-cement ratio of the design mix. Limit slumps to the following.

#### SLUMP TEST VALUES

PORTION OF STRUCTURE	SLUMP (inches)
Column, Beams, Girders, Slabs	3-6
Foundation Elements, Bedded Slabs and Cantilevered Beams and Slabs	2-5
Pavement	2-3

### C. Proportions

The proportions of all materials in concrete shall be subject to the approval of the Engineer. The Contractor shall employ on his own expense an approved testing laboratory which shall design the mixed proportions in accordance with ACI 211.01-85. Strength requirements shall be 21 Mpa (3000 psi) for footings, retaining walls, footing tie beams, cistern and suspended slabs; 27 Mpa (4000 psi) for columns, girders, beams; 17.2 Mpa (2500 psi) for slabs on grade, partitions, walks, & other non-structural members; and 10.5 MPa (1500 psi) for lean concrete, or as required by the Engineer. The adequacy of this mix shall be verified by a test on a minimum of 6 cylinders; 3 tested at 7 days, 3 at 28 days, in accordance with ASTM C39. These mixes shall be proved by preliminary tests 30 days before concreting and shall show a 28-day strength of 15 percent higher than the ultimate required. No substitution shall be made in the materials or mix with additional tests to show that the quality of concrete is satisfactory. If, at any time during the construction, the concrete resulting from the approved mix design proves to be unsatisfactory for any reason such as too much water, lack of sufficient plasticity to prevent segregation, honeycomb, etc., or insufficient strength, the contractor shall notify the Testing Laboratory and the Engineer. The laboratory shall modify the design, subject to the approval of the Engineer until a satisfactory concrete is obtained.

## 2.03 MIXING CONCRETE

### A. Site Mixed Concrete

- B. All concrete shall be machine mixed for at least 1 1/2 minutes after all materials including water are in the mixing drum. The time elapse between the introduction of the mixing water to the

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cement and aggregates and placing of the concrete in final position shall not exceed 45 minutes.

- C. Placing of material in mixer shall be done in such a way that the first batch of concrete materials in the mixer shall contain sufficient excess of cement, sand and water to coat the inside of the drum without reducing the cement content of the mixed to discharged. The tampering of concrete, that is, placing additional cement, aggregate or water during mixing period shall not be permitted.
- D. Let the mixer be of an approved size and type which will ensure a uniform distribution of material throughout the mass. Equip it with a DEVICE FOR ACCURATELY MEASURING, TIMING AND CONTROLLING THE AMOUNT OF MIXING WATER IN EACH BATCH and operate in accordance with the manufacturer's recommendations.
- E. No hand mixing shall be allowed except in case of emergency such as mixer breakdown during pouring operations and shall stop at the first allowed construction joint.
- F. Retempering of concrete shall not be permitted. The Contractor shall mix only such quantities that are required for immediate use and mixture which has developed setting shall not be used. Concrete which has been partially hardened shall not be retempered.
- G. Ready-Mixed Concrete
  - 1. Ready-mixed concrete, when used shall be batched, mixed, and delivered from a plant approved by the Engineer and shall be in strict accordance with the requirements set forth in ASTM C-94.
  - 2. The rate of delivery of the mixed concrete shall be such that the interval between placing of successive batches shall not exceed thirty (30) minutes. The elapsed time between the introduction of water to the cement and aggregate and completion of discharge shall not exceed one (1) hour or not more than 1 1/2 hours if a retarder is used. It should be kept constantly agitated during the transit period. Delivery tickets shall not exceed one (1) hour and contains the weight of sand, gravel and amount of cement and water added. The Contractor shall keep legible copies available for examination of the Engineer

### **3.00 EXECUTION**

#### **3.01 PREPARATIONS**

- A. Inspect and clean all forms and check all installations before placing concrete.
- B. Wet surfaces thoroughly and grout before placing concrete.
- C. Clean all laitance from previous pouring and possibly expose aggregates before renewing pouring.

#### **3.02 CONCRETE PLACING**

- A. Concrete shall be placed only after all formworks, installations of materials to be embedded and preparation of surface involved in the placing have been inspected and approved by the

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- Engineer. The Contractor shall provide equipment and shall employ methods which will minimize separation of aggregates from concrete mix.
- B. Water shall be removed from excavation before concrete is deposited. Any flow of water shall be diverted through proper side drains to a pump or be removed by other approved methods to avoid washing over freshly deposited concrete. Hardened concrete, debris and foreign materials shall be removed from interior of forms and from inner surfaces of mixing and conveying equipment. Reinforcements shall be secured in position, inspected and approved before pouring concrete. Runaways shall be provided for wheeled concrete handling equipments, such equipment shall not be wheeled over reinforcements nor shall runaways be supported on reinforcements.
  - C. Concrete shall be handled from the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of the ingredients. It shall be deposited in the forms in approximately uniform horizontal layers and as nearly as practicable in its final position to avoid rehandling.
  - D. Conveying or handling of concrete by the use of long; inclined chutes or pipes or more than three (3) meters shall not be permitted. Dumping of concrete into buggies buckets or wheelbarrows with a free fall or more than one (1) meter shall not be permitted. When placing operations would involve dropping the concrete more than 1 1/2 meters, it shall deposited through sheet metal or other approved conveyor. As for practicability, the conveyor shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly-placed concrete. After the initial set of concrete, the forms shall not be jarred and no strain shall be placed on the ends of the reinforcing bar which are being projected.
  - E. Concrete in columns shall be placed in one continuous operation. Concrete in girders, beam and slabs in superstructures shall be poured in a monolithic and continues manner. No construction joint shall be allowed on any part of the structure without the approval of the Engineer.
  - F. Consolidation: Consolidate all concrete in accordance with provisions of ACI 309R-87. Consolidate all layers of concrete greater than four inches in depth with high frequency, internal, mechanical vibrating equipment, supplemented by hand spading and tamping. Consolidate concrete slabs 4 inches or less in depth by wood tampers, spading and settling with a heavy leveling straight edge. Operator vibrators with vibratory element submerged in the concrete with a minimum frequency of not less than 6000 impulses per minute when submerged. Insert and withdraw vibrators approximately 18 inches apart. Penetrate the previously lift with the vibrator when more than one lift is required. Place concrete in 18-inch maximum vertical lifts. Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation of aggregates. Provide adequate number of units and power source at all times. Maintain spare units to ensure adequacy. If in the opinion of the Engineer, the equipment being used is not adequate to accomplish proper consolidation, the Engineer may order delay in proper placement of concrete until such equipment is available for use at the location of placement of concrete.

### 3.03 FLOOR FINISHES

Floor finishes shall be noted carefully by the Contractor. Prepare slabs suitable in surface and elevation to receive finishes. Consult Division 9 Finishes and its application.

### 3.04 CONCRETE JOINTS

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- a. Construction Joint  
Construction joints shall be provided where indicated in the Drawings or as directed by the Engineer. Joints not indicated on drawings shall be so made and locate as not to impair the strength of the structures. When a construction joint is to be made, the surface of the hardened concrete shall be thoroughly cleaned and all laitance removed. In addition, the joint shall be thoroughly wetted and sloshed with a coat of neat cement grout immediately prior to placing of new concrete.
- b. Expansion and Contraction Joints  
Expansion and contraction joints shall be provided where indicated and shall be in accordance with details.
- c. Preformed Strips  
Preformed strips shall be placed before the adjoining concrete of a joint is poured. The joint sealer shall be applied after concrete on both sides of the joint have been poured and after the joint lines have been trued.

### 3.05 PROTECTION AND CURING CONCRETE

- A. General.  
Concrete surfaces exposed to conditions causing premature drying shall be protected as soon as possible with canvas, straw, burlap, sand or other satisfactory materials and kept moist; or if the surfaces are not covered they shall be kept moist by flushing or sprinkling, as directed by the Engineer. All concrete shall be moist cured for a period of not less than seven consecutive days after placing by an approved method or combination of methods applicable to local conditions.
- B. Moist Curing  
The surface of the concrete shall be kept continuously wet with water for a period of seven (7) days, by spraying or covering with burlap or other approved material thoroughly saturated with water or keeping the covering wet by spraying or intermittent hosing. Water for curing shall be generally clean and free from any element which might cause objectionable staining or discoloration of the concrete.

### 3.06 REPAIR OF CONCRETE

- A. Correct all imperfections on concrete surfaces to produce concrete and concrete surfaces that conform to the requirements of this Section.
- B. Unless otherwise approved by the Engineer, repair of imperfections in formed concrete shall be completed after 24 hours of removal of forms.
- C. Large bulges and abrupt irregularities shall be removed by bushing, hammering and grinding.
- D. Honeycombed or otherwise defective area shall be cut out to solid concrete but to depth of not less than 25 mm. The edges of the cut shall be perpendicular to the surface of the concrete.
- E. All imperfections on formed surfaces shall be repaired by patching with cement mortar:
  - i. Use white cement in the concrete to provide a finish color matching the surrounding concrete, except that for exposed surfaces.
  - ii. Saturate the area to be patched and at least 150 mm adjacent thereto with water before placing the mortar.

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- iii. Mix the mortar approximately one hour before placing and remix occasionally during this period with a trowel without adding water.
- iv. Then brush a grout of cement and water, mixed to the consistency of paint, onto the surface to which the mortar is to be bonded. Compact the mortar into place and screed slightly higher than the surface.
- v. Finish patches on exposed surfaces to match the adjoining surfaces, after they have set for an hour or more. Cure patches as specified for the concrete.
- G. Use mortar filling placed under impact of mortar gun as drypack filling for holes too shallow for concrete filling and these holes should be no deeper than the far side of the reinforcement nearest the surface.
- H. Concrete filling shall be used for holes extending entirely through the concrete for holes which are greater in area than 1,000 square centimeters and deeper than 10 centimeters and for holes in reinforced concrete which are greater in area than 500 square centimeters and which extend beyond reinforcement..
- I. Filling shall be bonded tightly to the surfaces of the holes and shall be sound and free from shrinkage, cracks and drummy areas, after the fillings have been cured and dried.
- J. Exposed surfaces shall utilize plywood forms, and after the removal of forms, shall not be plastered, unless otherwise directed by the Engineer.
- K. All joint marks of the formwork shall be reworked to a smooth surface to match adjacent areas and to present a neat appearance.
- L. All materials, procedures and operations used in the repair of concrete shall be as directed by the Architect / Engineer.
- M. The cost of all materials, labor and equipment used in the repair of all materials shall be borne by the Contractor.

### 3.07 TEST OF CONCRETE

#### A. Concrete Samples and Testing

The Contractor shall be required to make test on concrete samples taken from actual pouring of concrete on site under the Supervision of the Engineer. Throughout the period the concrete is being poured into the forms and while spading operation are being done, sets of test samples in cylinder shall be taken from fresh concrete from the forms.

The Contractor shall employ, at his own expense, an approved testing laboratory which shall make the following test and immediately submit five copies of test reports to the Engineer. The following test shall be made each 10 cu.m. of concrete or fraction thereof, but not less than one (1) set of tests, shall be made from any one batch of concrete and all three (3) tests shall be made from the same batch.

##### 1. Compression Tests:

The Contractor shall furnish six (6) standard 150 x 300 mm cylindrical mould and place on the fresh concrete inside the cylinder in three separate equal layers rodded separately with 16mm diameter rod 25 strokes, with the tamping end rounded to a hemispherical tip of the same diameter. Level the surface with trowel and label the samples identifying the proportion of concrete, date taken and place taken. These samples are to be cured in the same manner as to the concrete in the construction cured.

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- a. Test one cylinder at the age of seven (7) days, and one cylinder at the age of twenty eight (28) days, in accordance with ASTM C31 and C39. Keep one cylinder in reserve for a fifty six day test, if the twenty eight day test does not meet the requirements.
  - b. The Contractor shall make additional cylindrical sample as required or as directed by the Engineer, to check strength of concrete in the construction.
2. Slump Tests:
  - a. To determine the consistency of workable fluidity of freshly-mixed concrete in the field, the Contractor shall keep all times a slump cone at the site. At least two slump test shall be made and the sample of concrete from which test specimens are made shall be representative of the entire batch and shall conform with the procedures as specified in ASTM C143-78.
  - b. Place freshly-mixed concrete in the slump cone 100 x 200 mm x 300 mm in equal layers. Rod each layer with 25 strokes of the tamping rod 16 mm diameter with the tamping end rounded to a hemispherical tip of the same diameter. Level the mould and lift at once. Measure the slump action immediately by getting the difference in height between the height of the mould and the top of the slumped concrete.
  - c. The slump for vibrated concrete shall be 50 mm minimum and 100 mm maximum provided that the required strength of concrete is obtained.
3. Test Reports:
  - a. The testing laboratory shall submit four copies of its test cylinder reports which are to include as far as applicable, the following items: Location of pour in the structure, concrete design, mix number, concrete design strength, type and manufacturer of cement, amount of any admixture used, slump tests, date of sampling, cylinder application number, days cured in the field, days cured in the laboratory, age at time of testing, crushing stress, type of failure, who made the samples, who shipped the samples to the laboratory and whether concrete strength meets the specifications.
4. Additional Tests:
  - a. If, in the opinion of the Engineer, based on cylinder strengths below specifications requirements or visual defects, concrete of poor quality has been placed, additional test shall be made as directed by the Engineer and at the expense of the Contractor. Test may be compression test on cored cylinder, ASTM C42, and /or load tests as outlined in ACI 318, Sec. 202, or as directed.

### 3.08 FAILURE OF TEST SAMPLES

- i. In any case of failure to meet specified strength, the Contractor may, at his expense, obtain concrete core samples from the poured concrete and have their compressive strength determined by a competent testing authority which shall be taken as a conclusive evidence of its strength and integrity, provided the curing will not impair the safety of the structure and can be satisfactorily replaced.
- ii. To determine adequacy of the structure, the Owner shall have the option to order load tests on parts of the structure where concrete strength tests are below 80% of those specified. These tests are to be done in accordance to ACI 318-89 recommendations and the cost are to be borne by the Contractor.
- iii. Demolition and concrete replacement, if recommended by the Engineer shall be borne by the Contractor.

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### 3.09 LIQUIDATED DAMAGES FOR FAILURE TO MEET CONCRETE REQUIREMENTS

For strength to concrete obtained on molded or drilled test specimen less than those required on Article 3.06, the Contractor shall pay to the Owner as liquidated damages, and not as a penalty or forfeiture. The following are the percentages of the proposed unit prices per cubic meter for the quantity of concrete directly and indirectly affected by the failure to meet strength requirements regardless of whether or not analyses of test results show that the concrete in place can still safely carry the design loads:

- A. For concrete less than one hundred percent (100%) but greater than ninety-two percent (92%) of specified strength, payment of thirty percent (30%) of the cost per cubic meter of concrete.
- B. For concrete equal to or less than ninety-two (92%) but greater than eighty-five percent (85%) of the specified strengths, payment of sixty-five percent (65%) of the cost per cubic meter of concrete.
- C. For concrete equal or less than eighty-five percent (85%) of the specified strengths, removal of the concrete deposited and its replacement at the expense of the Contractor.

### 3.10 INSPECTION

Concrete shall be proportioned, mixed and placed only in the presence of the Architect / Engineer. The Architect / Engineer shall be notified in advance to provide ample time for inspection of reinforcing steel bars before any mixing and placing of concrete is commenced.

*END OF SECTION 03300*

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## **SECTION 03400**

### **ARCHITECTURAL PRECAST CONCRETE**

#### **1.00 GENERAL**

##### **1.01 SCOPE OF WORK**

- A. Furnish all materials, labor, equipment, plant, tools, required to complete all architectural pre-cast mouldings, units, etc.
- B. See drawings for location and extent of work required.

##### **1.02 SUBMITTALS**

- A. Shop Drawings- Submit shop drawings showing mounting details for the approval of the Architect/Engineer.
- B. Samples- Submit sample of each type for the approval of the Architect/Engineer.

##### **1.03 DELIVERY, HANDLING AND STORAGE**

Handle, store and protect precast items both in transit and on jobsite to avoid chipping, breaking or contact with soil. Materials shall not be delivered unduly long before it is required for the proper conduct of work.

##### **1.04 QUALITY CONTROL**

- A. Ensure that the preceeding work is clean and ready to receive units.
- B. Check reinforcing steel dowels for straightness, proper alignment, spacing, size and length.
- C. Observe field proportioning of mortar. Visually check aggregate to determine uniformity of grading, cleanliness and moisture.
- D. Reject damaged materials and ensure good quality materials to be installed.
- E. Ensure that the joints are full of mortar and kept light during work.
- F. Check plumbness of units installed.
- G. Keep complete record of inspection.

#### **2.00 PRODUCTS**

##### **2.01 MATERIALS**

Refer to Section 01020 Summary of Materials and Finishes.

##### **2.02 CONCRETE MIXES**

- A. Normal-Weight Concrete Face and Back-Up Mixes: Proportion mixes by either laboratory trial batch or field test data methods according to ACI 211.1, using materials to be used on the Project, to provide normal-weight concrete with the following properties:

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1. Compressive Strength (28-Day): 20.7 Mpa (3000 psi).
2. Maximum Water-Cement Ratio at Point of Placement: 0.40.

### **2.03 MOLDS**

- A. Accurately construct molds, mortar tight, of sufficient strength to withstand pressures due to concrete-placing operations and temperature changes.
- B. Maintain molds to provide completed architectural precast concrete units of shapes, lines, and dimensions indicated, within fabrication tolerances specified.

### **2.04 FABRICATION**

- A. Accurately position cast-in anchors, inserts, plates, angles, and other anchorage hardware for attachment of loose hardware and secure in place during precasting operations. Locate anchorage hardware where it does not affect the position of the main reinforcement or the placing of concrete.
- B. Discard architectural precast concrete units that are warped, cracked, broken, spalled, stained, or otherwise defective unless repairs are permitted by Architect and meet requirements.

## **3.00 EXECUTION**

### **3.01 PREPARATION**

Clean laitance, dust, dirt, organic or other foreign materials from concrete surface upon which reinforced masonry is to be placed. Use sand blasting, if necessary to remove laitance from pores.

### **3.02 INSTALLATION**

- A. Install clips, hangers, and other accessories required for connecting architectural precast concrete units to supporting members and back-up materials.
- B. Mortar joints- Spread all bed joints with mortar to the full thickness of the face. Avoid fins of mortar that protrude into cells to be grouted.
- C. Install architectural precast concrete units plumb, level, and in alignment. Provide temporary supports and bracing as required to maintain position, stability, and alignment as units are being permanently connected.

### **3.03 CLEANING**

- A. Clean exposed surfaces of architectural precast concrete units after erection to remove weld marks, other markings, dirt, and stains.

1. Wash and rinse according to architectural precast concrete fabricator's recommendations. Protect other work from staining or damage due to cleaning operations.
2. Do not use cleaning materials or processes that could change the appearance of exposed architectural precast concrete finishes.

*END OF SECTION 03400*

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