

**SECTION 03310  
CAST-IN-PLACE CONCRETE**

**PART 1 - GENERAL**

**1.01 SCOPE**

This specification section covers all materials, equipment, and methods to be used by the CONTRACTOR in mixing, placing, testing, finishing, and curing cast-in-place concrete. The CONTRACTOR shall furnish all cement, aggregate, water, admixtures, and other materials and all labor, equipment, and supplies necessary or convenient to him for completing the work described in these Contract documents.

Cast-in-place concrete reinforcement and form work shall be as specified in the sections entitled "Cast-In-Place Concrete Reinforcement" and "Concrete Formwork" respectively of these Specifications.

**1.02 CLASSIFICATION OF CONCRETE**

Concrete shall be either Class A or Class B, as indicated on the Drawings or specified in these Specifications. If the class is not otherwise specified, the CONTRACTOR shall furnish Class A concrete.

In general Class A concrete shall be used for reinforced concrete cast-in-place in forms for slabs, footings, foundations, manholes, and similar reinforced concrete structures coming under the scope of ACI 318. Class B concrete shall be plain concrete and shall be used for pipe cradles, pipe and conduit encasement, bedding, grade correction, anchors, collars, thrust blocks, massive sections, and other non-reinforced concrete.

**1.03 GENERAL REQUIREMENTS**

All cast-in-place concrete shall be accurately formed and properly placed and finished as shown on the Drawings and specified herein.

The materials, aggregate grading, cement content, and placement methods specified herein are intended to provide a concrete that satisfies the minimum strength requirements, exhibits sufficient plasticity and cohesiveness to facilitate placement and reduce honeycombing and porosity, and incorporate a minimum water-to-cement ratio to minimize bleeding and shrinkage and to provide maximum water tightness. However, the CONTRACTOR may submit to the ENGINEER for review and approval alternate material requirements and placement techniques for achieving the desired results.

All Class A cast-in-place concrete shall be designed in accordance with the applicable requirements of ACI 318, latest edition.

**1.04 PRELIMINARY MIX DESIGN**

Before starting any concreting operations, the CONTRACTOR shall submit to the ENGINEER for approval a preliminary mix design for each class of concrete and for each size and gradation of aggregate and each consistency within a given class of concrete

intended for use in the work. The preliminary mix design submittals shall contain the following information for each: (including those items listed in the latest ASTM designations, if different from those specified)

A. FINE AGGREGATE (Sample per ASTM D 75)

1. Source and type
2. Sieve analysis per ASTM C 136
3. Magnesium sulfate soundness per ASTM C 88
4. Deleterious substance per ASTM C 117, C 123, and C 142
5. Saturated surface dry weight per cubic yard of concrete
6. Bulk specific gravity per ASTM 127
7. Fineness modulus as defined in ASTM C 125

B. COARSE AGGREGATE (Sampled per ASTM D 75)

1. Source and type
2. Sieve analysis per ASTM C 136
3. Abrasion loss per ASTM C 535
4. Magnesium sulfate soundness per ASTM C 88
5. Deleterious substances per ASTM C 117, C 123, AND C 142
6. Saturated surface dry weight per cubic yard of concrete
7. Bulk specific gravity per ASTM 128

C. CEMENT (Sampled per ASTM C 183)

1. Manufacturer, type, and ASTM designation
2. Sacks per cubic yard of concrete
3. Total gallons of water per sack (cu.ft.) of cement
4. Compressive strength at 7 days per ASTM C 109
5. Chemical analysis per ASTM C 114

- D. SLUMP per ASTM C 143
- E. AIR CONTENT per ASTM C 231
- F. UNIT WEIGHT per ASTM C 138
- G. TIME TO INITIAL SET at 70 Degrees F. per ASTM C 403
- H. COMPRESSIVE STRENGTH at 7, 14, and 28 days ages per ASTM C 192, and C 39. A total of 9 standard test cylinders shall be prepared and cured in the laboratory for each preliminary mix design, three of which shall be tested each at 7-, 14-, and 28-day ages.

I. ADMIXTURES

- 1. Manufacturer, type, and ASTM designation
- 2. Dosage and point of introduction into the mix.

A preliminary mix design shall not be considered acceptable if the concrete resulting from that mix design does not produce an average 28-day compressive strength at least 1,200 psi higher than that required, unless a standard deviation for compressive strength testing has been established for the concrete supplier using the methods described in ACI 214. If a standard deviation has been established, the strength used as a basis for selecting concrete proportions shall exceed the required 28-day strength by the amounts given in ACI 318, Section 4.2.2.1, based on the appropriate value of the standard deviation. If a standard deviation is utilized, the CONTRACTOR or concrete supplier shall furnish written evidence to the ENGINEER that the standard deviation has been determined in accordance with the methods described in ACI 214. A written statement from an independent testing laboratory may be considered satisfactory evidence of compliance.

Tests for compressive strength and all sampling and testing of aggregate and cement shall be conducted in accordance with the specified ASTM standards by an independent testing laboratory acceptable to the ENGINEER. Alternately, when approved by the ENGINEER, testing of cement and aggregate may be conducted at the point of manufacture by reputable cement and aggregate suppliers who regularly provide such testing services by experienced, competent personnel.

Tests for slump, air content, unit weight, and time to initial set may be conducted by the concrete supplier, providing such tests are performed in accordance with the specified ASTM standards by experienced, competent personnel using proper equipment.

The CONTRACTOR shall submit with each preliminary mix design four (4) copies of certified laboratory or mill test reports on all aggregate and cement incorporated in the preliminary mix design and four (4) copies of certified laboratory test reports on the compressive strength of the resulting concrete. Test

reports on aggregate and cement shall contain written evidence that clearly indicates that all cement and aggregate covered by the test reports conform in all respects to the applicable material requirements of this specification section.

Approval of the preliminary mix designs shall in no way be interpreted to relieve the CONTRACTOR of any responsibilities, duties, or obligations for providing concrete conform in to the requirements of this specification section.

If, during the course of concreting operations, the CONTRACTOR desires to use an alternate mix design differing from the approved mix design in order to obtain a desired workability, density, strength, or uniformity, he shall submit to the ENGINEER for approval the information specified herein on the proposed alternate mix design prior to its use.

If, based on the result of laboratory or field tests conducted during concreting operations, concrete prepared according to an approved mix design fails to satisfy the requirements of this specification section, the ENGINEER shall have the right to require that the CONTRACTOR develop and submit in the manner specified an alternate mix design that will provide concrete conforming to the requirements of this section. The need for a change in mix design will be based on the ENGINEER'S statistical analysis and interpretation of laboratory and field tests conducted during concreting operations. Statistical methods and interpretation of test results will be as described in ACI 214, and ACI 318, latest edition.

Any increased material costs resulting from changes in mix designs during construction shall be paid for by the CONTRACTOR and no separate payment will be made.

The cost of all materials, labor, equipment and all sampling and testing services required for the preliminary mix designs or for alternate mix designs during construction shall be paid for by the CONTRACTOR and no separate payment will be made.

## **1.05 QUALITY CONTROL DURING CONSTRUCTION**

### **A. CERTIFICATION OF MATERIAL COMPLIANCE**

During concreting operations, the CONTRACTOR shall furnish the ENGINEER written evidence that clearly indicates that the cement and aggregate used in each batch of concrete delivered to or mixed at the job site conforms in all respects to the applicable material requirements of this specification section. Satisfactory certified mill test reports from the cement or aggregate supplier may be considered as evidence of compliance provided that such testing is performed in accordance with the specified ASTM standards by experienced, competent personnel on a regular basis. In case of doubt as to the adequacy or accuracy of mill tests, the ENGINEER may require that the CONTRACTOR furnish, at no additional cost to the OWNER, test reports on the cement and aggregate from an independent testing laboratory acceptable to the ENGINEER. Certified reports or certificates indicating compliance of cement and aggregate shall be submitted to the ENGINEER before such materials are incorporated

into the work. The CONTRACTOR shall be responsible for any delays in the progress of the work due to delays in testing and reporting.

Certified reports submitted to the ENGINEER for laboratory or mill tests on cement and aggregate shall be based on tests conducted not earlier than 90 days prior to incorporation of these materials into the work.

The cost of all sampling and testing of cement and aggregate necessary to furnish satisfactory evidence of compliance shall be borne by the CONTRACTOR and no separate payment will be made.

## B. FIELD SAMPLING AND TESTING

During concreting operations, the ENGINEER will periodically require additional field inspection, sampling, and testing of cement, aggregate, and/or concrete by an independent testing laboratory in order to determine if the requirements of this specification section are being satisfied.

Field sampling and testing of cement, aggregate, and concrete will be performed according to the following latest ASTM Standards at a frequency determined by the ENGINEER.

### 1. AGGREGATE

- a. Sampling           ASTM D 75
- b. Testing            Any test specified in ASTM C 33

### 2. CEMENT

- a. Sampling           ASTM C 183
- b. Testing            Any test specified in ASTM C 150

### 3. CONCRETE

- a. Sampling           ASTM C 172
- b. Slump Test         ASTM C 143
- c. Air Content Test   ASTM C 231
- d. Making and Curing  
    Test Cylinders     ASTM C 31
- e. Compression  
    Strength Tests     ASTM C 39

Compressive strength testing will consist of making, curing, and testing cylinders of concrete. A total of four test cylinders will be prepared from each sample of concrete to be tested. Two test cylinders will be broken at an age of 7 days, two test cylinders will be broken at an age of 28 days. The minimum number of samples and test cylinders to be taken is as follows:

Concrete Class	Total Size of Pour	Number of Samples	Number of Cylinders
	03310-5		

Class A	1-4 cu. yds.	1	4
Class A or B	4-100 cu. yds.	1	4
Class A or B	101-200 cu. yds.	2	8
Class A or B	201-300 cu. yds.	3	12
Class A or B	Over-300 cu. yds.	1/100 cu.yd.	4/100 cu.yd.

Test cylinders will normally be laboratory-cured. However, the ENGINEER may require tests on field-cured specimens to check the adequacy of curing operations.

A slump test and an air content test will be performed on each sample of concrete tested for compressive strength.

Cement and aggregate will be subject to inspection, sampling, and field testing at the batching plant. Concrete will be subject to inspection, sampling, and field testing at the place of concrete placement. All field sampling, field testing, making and curing of field test cylinders, and laboratory testing performed during concreting operations for the purpose of determining if the requirements of this specification section are being satisfied shall be conducted by an independent testing laboratory selected by the OWNER and paid for directly by the OWNER and not as a part of this Contract.

The CONTRACTOR shall furnish the testing laboratory representative satisfactory samples of cement, aggregate, and concrete for inspection and testing purposes. The CONTRACTOR shall furnish any barrows, shovels, mixing boards, shaded area for preparing test cylinders, and similar equipment required by the testing laboratory representative for securing samples, making test cylinders, and conducting field tests.

No materials or concrete which fail to conform to the requirements of this specification section shall be incorporated into the work.

## **1.06 SHOP DRAWINGS AND ENGINEERING DATA**

Complete ENGINEERING and product data shall be submitted to the ENGINEER on all admixtures, curing compounds, hardeners, sealers, and waterstops in accordance with the requirements of the section entitled "Submittals" of these Specifications.

## **1.07 GUARANTEE**

Provide a guarantee against defective or deficient workmanship and materials in accordance with the requirements of the section entitled "Guarantees and Warranties" of these Specifications.

## **PART 2 - PRODUCTS**

### **2.01 GENERAL**

Concrete shall be composed of Portland Cement, fine aggregate, coarse aggregate, admixtures as specified herein, and water, so proportioned and mixed as to produce a plastic, workable mixture meeting the requirements of this specification section.

Materials and concrete not conforming to the requirements specified herein shall not be incorporated in the work.

### **2.02 MATERIALS**

#### **A. CEMENT**

All cement used in cast-in-place concrete shall be Portland Cement conforming to the requirements of ASTM C 150, and, unless otherwise approved by the ENGINEER, shall be Type 1. No cement of dark color shall be used. No re-sacked, lumpy or partially set cement shall be used. Each sack of cement shall contain not less than 94 pounds (net) of cement, and each sack of cement shall be deemed to have a volume of 1 cubic foot; and each 94 pounds, if weighed or measured in bulk, shall be deemed to have a volume of 1 cubic foot.

#### **B. FINE AGGREGATE**

Fine aggregate shall be natural siliceous river sand, consisting of hard, clean, sharp, strong, durable and uncoated particles, conforming to the requirements of ASTM C 33. The mortar strength developed in such test shall be 90 percent of that developed by standard Ottawa sand tested under identical conditions.

Fine aggregate shall be graded in conformance with the requirements of ASTM C 33, except that it shall have a fineness modulus of 2.40 minimum and 3.00 maximum and the material passing the No. 200 sieve shall not exceed 3.0 percent by weight of the total sample. Coal and lignite shall not exceed 0.5 percent by weight of the total sample for all concrete. The fineness modulus of fine aggregate incorporated in the work shall not vary more than 0.10 plus or minus from the fineness modulus of the fine aggregate in the appropriate preliminary mix design approved by the ENGINEER.

If the locally available sources of fine aggregate will not yield the required grading, the ENGINEER may approve alternate gradations if such deviations do not adversely affect the work. However, the amount retained on any individual sieve size shall not exceed 35 percent of the sample and the amount passing the No. 50 sieve shall not be less than 15 percent of the sample.

#### **C. COARSE AGGREGATE**

Coarse aggregate shall consist of clean, natural, washed gravel or crushed stone suitably processed and conforming to the requirements of ASTM C 33, Class Designation 3S.

Coarse aggregate as delivered to the mixing plant shall be graded, or individual sizes shall be so combined as to fall within the grading requirements corresponding to the following grading size numbers, as contained in Table 2 of ASTM C 33:

Maximum Aggregate Sizes, Inches	Grading Size No.
3/4	67
1	57
1-1/2	467
2	357

The maximum size of aggregate shall be no larger than one-fifth of the narrowest dimension between sides of forms within which concrete is to be cast nor larger than three-fourths of the minimum clear spacing between reinforcing bars, or between bars and forms. Coarse aggregate shall be limited to 3/4 inch maximum size for pumped concrete.

#### D. WATER

Water used in mixing concrete shall be fresh, clean, potable water free from injurious amounts of oil, acid, alkali, vegetable, sewage, and/or organic matter. Water shall be considered as weighing 8.33 pounds per gallon.

#### E. ADMIXTURES

All concrete shall contain an air entraining admixture conforming to ASTM C 260 in order to provide an entrained air content of 5 + 1 percent by volume. Air entraining admixtures shall be W. R. Grace "Darex AEA", Master Builders "MB-VR", Protex "AES", Sika "AEA", or equal.

All concrete shall contain a chloride-free, water reducing admixture or plasticizer conforming to ASTM C 494, Type A. Water reducing admixtures shall be W. R. Grace "WRDA-HC", Sika "Plastocrete", Gifford-Hill "PSI Normal", Master Builders "Pozzolith Normal", Chem-Masters "WR-77", or equal.

Accelerators and retarders may be used under adverse placement conditions when authorized in writing by the ENGINEER. Accelerators shall be calcium chloride conforming to ASTM D 98, dispensed as a solution. Calcium chloride content shall not exceed 1 percent of the cement content by weight. Retarders shall be chloride-free water reducing and retarding admixtures conforming to ASTM C 494, Type D. Retarders shall be W. R. Grace "Daratard-HC", Sika "Plastiment", Protex "Protard", Gifford-Hill "PSI Retarder", Master Builders "Pozzolith Retarder", or equal.

The admixture content, batching method, and time of introduction into the mix shall be in strict accordance with the manufacturer's recommendations.

### **2.03 MEMBRANE CURING COMPOUND**

Membrane curing compound shall have a 100 percent resin base and shall be of the colorless type with a fugitive dye added conforming to ASTM C 309, Type I, Class B. The membrane curing compound shall contain sufficient dye to produce a definite, distinguishing color. Curing compound shall be compatible with liquid hardeners and epoxy sealers.

Membrane curing compound shall be Protex "LR-151", Sonneborn "Hydrocide-309", W. R. Grace "Horncure 30D", Chem-Masters "Kurex 3", or equal.

### **2.04 POLYETHYLENE FILM**

Polyethylene film shall conform to Product Standard PS 17 and, unless otherwise specified or shown on the Drawings, shall have a thickness of 6 mils.

### **2.05 EPOXY BONDING AGENT**

Epoxy bonding agents shall be specially formulated to bond fresh concrete to existing concrete. Epoxy bonding agents shall be two-component polysulfide or polyamide epoxies containing 100 percent solids. Epoxy bonding agents shall be insensitive to moisture during cure. When cured at a temperature of 63 Degrees F., neat epoxy bonding agent shall have a one-day compressive strength of not less than 5,000 psi and a 28-day compressive strength of not less than 12,000 psi, when tested in accordance with ASTM D 695, and shall have a 28-day tensile strength of not less than 3,500 psi, when tested in accordance with ASTM D 638.

### **2.06 WATERSTOPS**

Waterstops shall be manufactured of PVC and shall be of the ribbed type with center bulb. Waterstops shall have a nominal width of 6 inches and shall be as manufactured by W. R. Meadows, Vulcan Metal Products; W. R. Grace; or equal. Waterstops placed in concrete shall be continuous. Lapped joints shall not be permitted.

### **2.07 CHEMICAL HARDENER**

Unless otherwise specified, all interior concrete floors of shops, garages, and vehicle service areas shall be treated with a liquid hardener composed of magnesium and zinc fluorosilicates combined with an anionic surfactant for improved wetting penetration. Liquid hardener shall be colorless, nontoxic, nonflammable, and compatible with and providing good adhesion for subsequent toppings and/or coatings. Liquid hardener shall be suitable for use on new or old concrete floors and shall comply with Corps of Engineer Specification 204. Liquid hardener shall be Sonneborn "Lapidolith", Protex "Lithoplate", L & M "Fluo Hard", or equal.

## 2.08 EPOXY FLOOR SEALER

Epoxy floor sealer shall be a two-component, 100 percent solids, epoxy coating that provides a smooth, tough, flexible, wear abrasion, and chemical resistant surface. Epoxy floor sealer shall be applied only where shown on the Drawings. Sealer shall be U.S.D.A. approved for use in food processing plants. Unless otherwise specified, sealer shall be colored gray. Epoxy sealer shall be Chem-Masters "Durakote", Sonneborn "Sonoplex", L&M "Dynaflor", or equal.

## 2.09 VAPOR BARRIER

Unless otherwise specified, all interior concrete slabs on grade in buildings shall be furnished with an FHA approved vapor barrier under the concrete slab. Vapor barrier shall be constructed of a multi-ply lamination of polyethylene film and glass scrim reinforced paper to form a moisture, scuff, and puncture resistant membrane. Moisture permeance shall not exceed 0.10 perms in accordance with ASTM E96, Procedure A. Vapor barrier shall be St. Regis Paper Company "Moistop", Glas-Kraft "Plybar", or equal.

## 2.10 STRENGTH

Concrete ingredients shall be selected, proportioned, and mixed in such a manner as will produce a watertight durable concrete that will develop the following minimum compressive strengths at an age of 28 days when sampled, cured, and tested in accordance with the procedures specified in ASTM C 31 and C 39:

Class of Concrete	AGE	Average of Three Consecutive Specimens	Minimum Any One Specimen
A	28 days	4,000 psi	3,500 psi
B	28 days	2,500 psi	2,000 psi

Should the average compressive strength of three consecutive specimens or the compressive strength of any single specimen fall below the minimum strengths specified above, the ENGINEER shall have the right to order a change in the mix design for the remaining portion of the work. The ENGINEER shall also have the right to order additional curing of the affected concrete followed by cores taken in accordance with ASTM C 42 and ACI 318, all at the expense of the CONTRACTOR. If the additional curing does not bring the average compressive strength of three cores taken in the affected area to at least the minimum strength specified, the ENGINEER may require that the CONTRACTOR strengthen the structure by means of additional concrete and steel or he may require that the CONTRACTOR replace the affected portions. The cost of all such changes in mix designs and any modifications to or replacement of deficient concrete shall be borne by the CONTRACTOR at no additional cost to the OWNER.

## 2.11 CONSISTENCY

Concrete shall be of such consistency and composition that it can be worked readily into the corners and angles of the forms and around the reinforcement without excessive spading and without permitting the materials to segregate or free water to collect on the surface. When dropped from the discharge chute, the concrete mass should flatten out at the center and spread out slowly at the edges.

The proportions shall be adjusted to secure the lowest water-cement ratio which is consistent with good workability, a plastic cohesive mixture, and one which is within the following slump range as determined in accordance with ASTM C143:

CONCRETE USE	SLUMP IN INCHES
Walls	2-1/2 - 4
Floors and Slab	2 - 3
Beams	2 - 3
Blocks and Footings	2 - 4

Concrete having a slump greater than one inch over the specified maximum shall be rejected.

In pumped concrete the maximum slump of the concrete at the suction of the pump may be increased above the maximum specified slump by the amount of slump loss in the pumping system up to a maximum of one inch. The amount of slump loss shall be the difference between slump tests made at both ends of pumping system, and shall be limited to a total loss of one inch. If tests indicate a loss greater than one inch, the CONTRACTOR shall take corrective measures acceptable to the ENGINEER.

For thin sections and construction with limited clearance between reinforcing steel and when placement conditions preclude the use of vibrators, the ENGINEER may authorize the use of concrete having a slump of 5 inches.

## PART 3 - EXECUTION

### 3.01 STORAGE OF MATERIALS

Cement shall be shipped to the site of the mixer plant in bulk or in paper or cloth bags, at the option of the CONTRACTOR. Upon arrival it shall be stored immediately in a thoroughly dry, weather-tight and properly ventilated building or enclosure with adequate provisions for the prevention of absorption of moisture. It shall be stored in a manner that will permit easy access for inspection and identification of each shipment. If cement is to be stored at the job site, storage facilities shall be provided by and at the expense of the CONTRACTOR and approved by the ENGINEER prior to arrival of the first shipment. Cement which has become caked or lumpy shall not be used.

Sand and coarse aggregates shall be stored in separate stockpiles at points selected to provide maximum drainage and to prevent the inclusion of a foreign material during rehandling. Stockpiles of coarse aggregates shall be built in horizontal layers to avoid

segregation and breakage. Where concrete volumes require batching of various aggregate sizes, a separate stockpile for each size shall be maintained. The bottom 6 inches of aggregate piles shall not be used.

### 3.02 PROPORTIONING

Concrete materials shall be accurately proportioned and mixed to produce a homogeneous and workable mixture having the consistency and minimum compressive strength specified herein.

Concrete materials shall be proportioned by weight. The types of equipment and methods used for measuring ingredients shall be acceptable to the ENGINEER.

The amount of water and cement used shall be the minimum amount necessary to produce a concrete mixture of the required strength and consistency, but in no case shall the water-to-cement ratio exceed that specified herein nor shall the cement content be less than that specified herein.

Compressive strength may not necessarily be the most critical factor in proportioning concrete mixes since other factors, such as durability and watertightness, may impose lower water-cement ratios than are required to meet strength requirements. In such cases compressive strength will, of necessity, be in excess of that specified.

Minimum cement contents and maximum water-to-cement ratios shall be as follows:

Factor	Class of Concrete	Maximum Aggregate Size			
		2"	1-1/2"	1"	3/4"
Minimum Cement Factor Sacks/cu. yd.	A	5.3	5.8	6.2	6.6
	B	5.0	5.5	5.9	6.3
Maximum Water-to-Cement Ratio, lb./lb.	A	0.49	0.49	0.49	0.49
	B	0.62	0.62	0.62	0.62
Maximum Water-to-Cement Ratio, Gal./Sack	A	5.5	5.5	5.5	5.5
	B	7.0	7.0	7.0	7.0

The water content of the mix shall be based on the total amount of water in the mixture, including any free water in the aggregate or adhering to the surface of the aggregate, but not including water absorbed by the aggregate.

The total volume of aggregate to be used in each cubic yard of concrete shall be determined by recognized standards for designing concrete mixes, utilizing the actual screen analysis of the aggregates.

The proportion of fine and course aggregate shall be such that the ratio of the course to the fine based on weight shall not be less than 1.0 nor more than 2.0, nor shall the amount of coarse material be such as to produce harshness in placing or honeycombing in the structure.

### 3.03 MIXING CONCRETE

The mixing equipment used by the CONTRACTOR shall be capable of combining the aggregates, cement, admixtures, and water within the time specified into a thoroughly mixed and uniform mass.

Concrete shall be mixed by one of the three following methods: (1) by the operation of one or more batch-type mixing plants, each with a rated capacity of 1/2 cubic yard or more, installed at the site of the work; (2) by the operation of a proportioning plant installed in the vicinity of the work and the use of transit mixers for mixing concrete and transporting it to the forms; or (3) by the use of ready-mixed concrete from a central mixing and proportioning plant. The method selected by the CONTRACTOR shall be subject to the approval of the ENGINEER.

The mixing and proportioning plants shall be provided with adequate equipment and facilities for accurate measurement and control of the quantities of material and water used in the concrete and for readily changing the proportions to conform to the varying conditions and requirements of the work.

#### A. STATIONARY MIXED CONCRETE

Stationary mixing shall be done in a batch mixer of approved type which will ensure a uniform distribution of the materials throughout the mass. The equipment at the mixing plant shall be so constructed that all materials including the water entering the drum can be accurately proportioned and be under control. The cement and aggregate shall be proportioned by weight. No volumetric batch shall be allowed. The mixer shall be equipped with an automatic timing device made to lock the discharge level before aggregate and cement enter the drum, and to release such level only after the specified mixing time has elapsed. Stationary mixers shall be in accordance with the "Concrete Mixer Standards" adopted by the Mixer Manufacturer's of the Associated General CONTRACTORS of America and shall bear a plate giving the manufacturer's rated capacity of the mixer.

The entire batch shall be discharged before recharging. The volume of the mixed material per batch shall not exceed the manufacturer's rated capacity of the mixer. Mixing of each batch shall continue for the period indicated herein, during which time the drum shall rotate at a peripheral speed as recommended by the manufacturer.

The mixing time shall be as follows:

Capacity of Mixer	Mixing Time in Minutes
1/2 cubic yards	1-1/4
3/4 to 1 1/2 cubic yards	1-1/2
Larger than 1-1/2 cubic yards	2

The mixing time shall be measured from the time that all cement and aggregates and most of the water are in the mixer. Excessive over mixing, requiring additional water to preserve the required consistency will not be permitted. All of the mixing water shall be introduced before one-fourth of the total mixing time has elapsed.

## B. TRANSIT MIXED CONCRETE

The type, capacity, and manner of operation of the mixing and transporting equipment for transit ready-mixed concrete shall conform to the current "Standards for Operation of Truck Mixers and Agitators of the National Ready-Mixed Concrete Association," the "Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau," and ASTM C94. Transit mix concrete trucks shall be equipped with an automatic device for recording the number of revolutions of the drum during the mixing period. Each mixer and agitator shall have attached thereto in a prominent place, a metal plate or plates, installed by the manufacturer, on which is plainly marked the capacity of the drum in terms of the volume of mixed concrete and the speed of rotation for the agitating and mixing speeds of the mixing drum or blades. Each mixer shall have identification number painted on the truck in such a location that it can be easily read from the batching platform.

The total volume of materials introduced into the mixer shall not exceed the manufacturer's guaranteed mixing capacity. If the concrete so mixed does not meet the uniformity requirements of this subsection, the amount of materials charged into the mixer shall be reduced. The drum of the mixer shall be completely emptied of any previously mixed load. The proper proportions of aggregate, cement, and water for each load of concrete shall be placed in the mixer and shall be mixed therein for not less than 70 nor more than 100 revolutions of the drum or blades at the speed designated by the manufacturer of the equipment as the mixing speed. Additional revolutions of the drum shall be at the speed designated by the manufacturer of the equipment as the agitating speed; however, immediately prior to discharging the concrete, the drum shall be revolved at the mixing speed for a minimum of three minutes. The revolving of the drum shall be continuous until the concrete is completely emptied from the drum.

When Class A concrete is being placed, all wash water shall be emptied from the mixer before any portion of the succeeding load is placed therein. For Class B concrete the mixer shall be empty or may carry no more than 10 gallons of water in the drum.

Water added at the point of discharge shall only take place with the approval and in the presence of the ENGINEER. Water so added shall be mixed into the load for a minimum mixing time of three minutes. Water shall not be added to the load during the transit.

The total elapsed time between the addition of water to the cement and aggregate or the addition of cement to the water and aggregate and the placement of the concrete in the forms shall not exceed 90 minutes. During hot weather or conditions contributing to quick setting, the total elapsed time permitted may be reduced at the direction of the ENGINEER to 45 minutes. When the concrete cannot be delivered to the forms within the time period specified, a water-reducing and retarding admixture may be used subject to the approval of the ENGINEER. Such use of a water reducing retarder will

be permitted only as necessary to supplement (not to replace) other acceptable hot weather procedures. The retarding admixture used shall not interfere with strength development and other properties of the concrete and its use shall be carefully controlled by the concrete supplier. Before any such admixture is permitted, it shall be tested with job site materials under job conditions to determine its compatibility with the other materials and its ability under these conditions to produce the desired properties.

Addition of water at the job site to offset evaporation of mixing water shall be done with the ENGINEER'S approval and in his presence using water in the form of a cement paste having the same water-to-cement ratio as the batch in the transit mixer. Following addition of the cement paste, the mixer drum or blades shall be rotated a minimum of 70 revolutions. Addition of water during transit to offset evaporation losses shall not be permitted.

Prolonged mixing, even at agitating speed, shall be avoided where feasible by stopping the mixer and then agitating intermittently.

A legible certified weigh master's certificate shall be prepared for each load of ready-mixed concrete. A legible copy of the certified weigh master's certificate shall be submitted to the ENGINEER by the truck operator at the time of delivery. The weigh master's certificate shall contain the following information:

1. Name of Vendor
2. Name of CONTRACTOR
3. Number of cubic yards in the load
4. Actual weights of cement and of each size of aggregate in the load
5. Amount of water added at the plant
6. Amount of free water in the aggregate
7. Brand and type of cement
8. Brand and amount of admixture
9. Time and date of batching

When mix proportions have been approved for a project and are identified by a mix number, the ENGINEER may waive the foregoing and accept a legible certified weigh master's certificate which shall contain the following information:

1. Name of Vendor
2. Name of CONTRACTOR
3. Number of cubic yards in the load

4. Mix designation number
5. Amount of water added at the plant (including free water in aggregate)
6. Time and date of batching.

Space shall be provided on the certificate so that amount of water and cement added on the job may be indicated.

### **3.04 CONVEYING CONCRETE**

Concrete shall be conveyed from the mixer to the place of final deposit by methods which will prevent separation or loss of the materials. Equipment for chuting, pumping, and pneumatically conveying concrete shall be of such size and design as to insure a practically continuous flow of concrete at the delivery end without separation of the materials.

If the concrete is to be transported more than fifty feet in carts or buggies, they shall be equipped with pneumatic tires. Concrete delivered to the carts, buggies or conveyors from spouts, troughs, or mixer trucks shall not have a free fall of more than three feet. Separation or loss of ingredients shall be prevented while transporting the concrete. Delivery carts, buggies, conveyor trucks or barrows shall be kept on temporary runways built over the floor system; runway supports shall not bear upon reinforcing steel or fresh concrete.

### **3.05 PLACING CONCRETE**

#### **A. GENERAL**

Prior to placing concrete, the CONTRACTOR shall ensure that all reinforcement is securely and properly fastened in position and protected against displacement, that all items to be embedded in the concrete are in place and securely anchored in position, that all forms have been thoroughly coated or wetted, that all form ties at construction joints have been retightened, that concrete surfaces to be covered have had all free water, form coating, loose concrete, and debris removed, and that all conveyances, buggies, and barrows are clean and wetted.

The CONTRACTOR shall inform the ENGINEER at least 24 hours in advance of the times and places at which he intends to place concrete. The ENGINEER will make a final inspection of forms, reinforcing steel, screeds, construction joints, openings, anchors, pipe sleeves, conduit, and inserts. No concrete pour shall be started until the condition of the forms and place of pouring has been inspected and approved by the ENGINEER.

Concrete shall not be placed when the sun, wind, heat or humidity prevents proper placement and consolidation.

No water or cement shall be added to the mix without the ENGINEER'S approval or in his absence. No partially hardened concrete shall be deposited.

## B. PLACING CONCRETE

Unless otherwise specified, all concrete shall be placed upon clean, damp surfaces, free from water, and never upon soft mud, dry absorbent earth or rock, or upon fills that have not been subjected to approved tamping to provide ultimate settlement.

Groundwater shall be kept below subgrade until the concrete has set. When subgrade is dry earth, it shall be thoroughly dampened with water to ensure that no moisture will be absorbed from fresh concrete.

Where concrete is placed against gravel or crushed rock which does not contain at least 25 percent of the material passing a No. 4 sieve or where shown on the Drawings or directed by the ENGINEER, surfaces against which concrete is cast shall be covered with polyethylene film to protect the concrete from loss of water.

Joints in the film shall be lapped at least 12 inches and taped. The polyethylene film shall be protected against puncture from the underlying crushed rock by a cushion of natural or imported sand meeting the requirements of ASTM D 1073 placed on top of the crushed rock. Where concrete is placed against rock, all loose pieces of rock shall be removed and the exposed surface cleaned with a high pressure hose.

Place vapor barrier under designated interior concrete slabs on grade. Sheeting shall extend the full area of the slab and shall be turned up or down to footings as indicated. Lap all seams at least 12 inches and seal per manufacturer's instructions. Install reinforcement with care so as not to puncture vapor barrier. Tape all cuts, tears, punctures, and pipe penetrations before pouring concrete.

To prevent segregation of the mix, concrete shall be deposited in its final position in batches without being moved laterally in the forms more than 5 feet. A crane and a bottom dump concrete bucket shall be used wherever possible. Unless authorized by the ENGINEER, no concrete shall be dropped freely into place from a height of greater than 5 feet. Concrete shall be deposited in walls by means of prefabricated, rectangular tremies, constructed in short sections and spaced laterally not over 5 feet apart. Special care shall be observed to avoid slopping concrete over forms when placing.

The limits of each concrete pour shall be predetermined by the CONTRACTOR and shall be acceptable to the ENGINEER. All concrete within such limits shall be placed in one continuous operation.

After the concrete has been deposited, it shall be distributed over the entire area within the forms in approximately horizontal layers of not more than 18 inches in depth and shall be brought up evenly in all parts of the form. Each layer of concrete shall be plastic when covered with the following layer and the forms shall be filled at a rate of vertical rise of not less than 2 feet per hour nor more than 6 feet per hour.

Should a layer of concrete reach its initial set before the next lift can be placed or should more than 60 minutes elapse between placement of successive concrete lifts, the CONTRACTOR shall cease placement of concrete until the surface of the previous lift

is prepared in accordance with the procedures specified in Part 3.08, Construction Joints, of this specification section. Workmen shall not walk on concrete during placing or finishing with any earth or foreign matter on footgear. Hand spreading shall be done with forks and shovels, not rakes.

Concrete shall be placed and compacted in wall or column forms before any reinforcing steel is placed in the structural system to be supported by such walls or columns. The portion of any wall or column placed monolithically with a floor or roof slab shall not exceed 6 feet of vertical height. Concrete in walls or columns shall set at least two hours before concrete is placed in the structural systems to be supported by such walls or columns. Brackets, haunches and fillets shall be poured monolithic with the floor or roof slab system.

### C. COMPACTION

During and immediately after placement, concrete shall be thoroughly compacted and worked into all corners and angles and around reinforcement and embedded fixtures in a manner to fill all voids, prevent honeycombing against the forms and avoid segregation of coarse aggregate. This operation shall be performed by the use of spades or forks and internal vibrators.

Vibration shall be transmitted directly to the concrete and in no case shall it be transmitted through the forms. Vibrator driving mechanisms shall revolve at not less than 7,000 rpm. The vibration shall be sufficiently intense to cause the concrete to flow and settle readily into place and to visibly affect the concrete over a radius of at least 18 inches. Vibration shall be supplemented by manual forking or spading adjacent to the forms on exposed faces in order to secure smooth, dense surfaces. Special care shall be taken to ensure consolidation around reinforcement, pipes and other shapes built into the work. Vibrators shall be kept in motion at all times to prevent excessive vibration in one spot. The operation shall be continuous and all concrete shall be in final position before initial set has started.

In addition to the vibrators in actual use while concrete is being placed, the CONTRACTOR shall have on hand at least one operable vibrator as a spare in case of equipment failure. No concrete shall be placed until all vibrating equipment, including spares, is at the placement site.

Concrete shall be thoroughly compacted prior to top finishing. All laitance, debris, and surplus water shall be removed from concrete surfaces at tops of forms by screeding, scraping, or other effective means. Wherever the top of a wall will be exposed to weathering, the forms shall be overfilled and after the concrete has been compacted, the excess shall be screeded off.

### D. PLACEMENT SEQUENCE

Unless otherwise indicated on the Drawings or directed by the ENGINEER, the following placement sequence shall be followed to reduce the effect of shrinkage in producing cracking:

1. BOTTOM SLAB

A center section (as outlined by the construction joints shown on the Drawings) shall be placed first. Not less than 72 hours after the center section has been placed, the Contractor may proceed with the placement of an adjoining section. Sections shall be placed alternately, first on one side and then on the other side of previously placed sections. Pours shall be scheduled so that two adjacent sides of each section are free, except at closures.

2. WALLS

Walls shall be divided into sections by the construction joints shown on the Drawings. A section near the center of each wall shall be placed first. Sections shall be placed alternately, first on one side and then on the other side of the previously placed section. Pours shall be schedule so that one end of each section is free, except at corner closures.

3. FOOTINGS

Footings, except for wall footings, shall be poured in one operation with no joints.

E. REQUIREMENTS DUE TO ADVERSE WEATHER CONDITIONS

No concrete shall be placed during rain. No concrete shall be placed if rain is forecast unless there is sufficient time to complete the placement and finishing. All concrete placed prior to rain shall be protected by whatever means necessary to prevent damage to finish or water entering the mix. Protection equipment and materials shall be on hand prior to placement operations. Freshly placed concrete shall be protected from scour by flowing water and from mud deposits or other injurious conditions.

Except as modified herein, cold weather concreting shall comply with ACI 306. The temperature of concrete at the time of placing shall be not less than shown in the following table for the corresponding ambient outdoor air temperature (in shade) existing at the time of placement:

Ambient Outdoor Air Temperature	Minimum Concrete Temperature
Below 35 Degrees F.	70 Degrees F.
Between 35 Degrees F. and 45 Degrees F.	60 Degrees F.
Above 45 Degrees F.	45 Degrees F.

Placing of concrete when the ambient air temperature at the time of placement is 45 Degrees F. or less shall be done only when specifically authorized by the ENGINEER using concrete heated in a manner acceptable to the ENGINEER. If the use of heated concrete is authorized, the temperature of the concrete at the time of placement shall not exceed 80 Degrees F.

Adequate means shall be provided for maintaining the temperature of the air surrounding the concrete at 70 ° F for three days, or 50 ° F for five days, or for as long as is necessary to ensure proper curing of the concrete. Rapid cooling of the concrete shall be prevented. Housing or covering or other protection used in connection with heating shall remain in place and intact at least 24 hours after the artificial heat is discontinued. The use of calcium chloride or other chemicals to prevent freezing shall not be permitted.

Except as modified herein, hot weather concreting shall comply with the requirements of ACI 305. Hot weather precautions shall be taken whenever the maximum ambient outdoor air temperature (in shade) during the day exceeds 85 Degrees F. When rapid mixing water evaporation in transit causes the concrete to be delivered in an unworkable condition, initial correction may be made at the job site, provided that water added is in the form of cement paste having the same water to cement ratio as the batch in the truck, and provided that the drum or mixer blades be operated at mixing speed for at least 70 revolutions after the paste addition. Once need for water has been observed, subsequent additions shall be at the batching plant until the need has passed. Correction shall consist of a simultaneous and proportionate increase of water and cement, up to 10 percent of the stated quantity of each material in the batch. Such increases in cement shall not constitute grounds for an increase in the Contract Price.

The temperature of concrete at the time of placement shall not exceed 85 ° F.

During hot weather, extra caution shall be taken to prevent rapid evaporation of water. Forms shall be kept cool by frequent wettings. Flat work shall be protected from drying winds, direct sun, and high temperatures whenever conditions of temperature and humidity are such as to cause plastic shrinkage cracking.

In order to prevent plastic shrinkage cracking due to rapid evaporation of moisture, no concrete shall be placed when the rate of evaporation, determined by using Figure 2.1.4 in ACI 305, equals or exceeds 0.2 pound per square foot per hour.

### **3.06 FINISHING**

#### **A. FINISHING FORMED SURFACES**

All permanently exposed surfaces shall be expected to be smooth and of uniform texture and appearance. Surfaces to be rubbed shall include all submerged concrete surfaces that can be seen when water is drained. Rubbing may be omitted for minor blemishes on buried surfaces or on exposed surfaces that cannot normally be seen, such as inside covered tanks. Final determination for which surfaces are to be rubbed is to be the decision of the ENGINEER. All holes, pits or imperfections in the surface of the concrete shall be cleaned with a wire brush, thoroughly wetted and completely filled with damp cement mortar composed of 1 part Portland Cement to 2 parts fine aggregate. The entire surface shall be left smooth and all lines or markings shall be smoothed over to obtain uniform appearance. In the event the CONTRACTOR fails to

obtain a satisfactory appearance of the concrete in the opinion of the ENGINEER, the entire surface shall be thoroughly wetted down, kept wet continuously and rubbed with a No. 20 Carborundum stone until all lines, markings and surplus materials have been removed from the surface and until the surface shows a uniform smooth finish. After rubbing is completed, the concrete surface shall be washed clean with water. Rubbing may be done either by hand or with power tools.

## B. FINISHING UNFORMED SURFACES

No surface treatment will be required for buried or permanently submerged concrete not forming an integral part of a structure except that required to obtain the surface elevations or contours and surfaces free of laitance. The unformed surfaces of all other concrete shall be screeded and given an initial float finish followed by additional floating followed by troweling where required. Care shall be taken that no excess water is present when the finish is made. No special concrete or cement mortar topping course shall be used unless so shown on the Drawing.

### 1. SCREEDING

All slabs shall be screeded to an even surface by the use of a straight edge and screeding strips accurately and securely set to the proper level. Screeds shall be such type and so arranged so as not to interfere with the top bar reinforcement.

Screeding shall provide a concrete surface conforming to the proper elevation and contour with all aggregates completely embedded in mortar. All screeded surfaces shall be free of surface irregularities with a height or depth in excess of 1/4 inch as measured from a 10-foot straight edge.

### 2. FLOATING

Screeded surfaces shall be given an initial float finish as soon as the concrete has stiffened sufficiently for proper working. Any piece of coarse aggregate which is disturbed by the float or which causes a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance with no unnecessary working of the surface.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a finish of uniform texture and color. Unless additional finishing is specifically required, the completed finish for unformed surfaces shall be the float finish produced by the second floating.

Floating shall be performed with hand floats or suitable mechanical compactor floats.

### 3. BROOMING

Surfaces of equipment bases and curbs and sidewalks shall be given a light broom finish providing a nonslip surface. Brooming shall be done after the second floating and for traffic areas shall be at right angles to the normal traffic direction.

#### 4. TROWELING

Surfaces to be covered with resilient floor coverings and other surfaces designated on the Drawings to be troweled shall be steel trowel finished. Trowel finishing will not be required for floors which are normally submerged. Troweling shall be performed after the second floating when the surface has hardened sufficiently to prevent an excess of fines being drawn to the surface. Troweling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

#### 5. EDGING

All permanently exposed edges of unformed surfaces shall be chamfered with a 3/4 inch approved edging tool unless other edge treatment is indicated on the Drawings.

### 3.07 CURING

All concrete shall be protected from loss of moisture by curing for at least 14 days following placement. Curing operations shall take place immediately after concrete finishing is complete or forms are removed. Breaking of form ties or otherwise breaking the seal between the concrete surface and the form shall be considered form removal.

Curing shall be accomplished by water curing, membrane curing, film curing, or any other curing method acceptable to the ENGINEER which does not injure or discolor exposed surfaces nor destroy the bond on surfaces to receive subsequent concrete pours or protective coatings.

#### A. WATER CURING

Concrete surfaces being water-cured shall be kept constantly and visibly wet for a period of not less than 14 days. Water saturation of concrete surfaces shall begin as quickly as possible after the initial set of the concrete. The rate of water application shall be regulated to provide complete surface saturation with a minimum of runoff.

Slabs poured on grade and decks may be water-cured by ponding or by covering with wet burlap sacks, sand, or sawdust and keeping this covering continually and visibly wet during this period. Standard canvas seep hose placed in parallel runs on 8-foot centers is recommended for ponding.

Walls may be cured by leaving the forms tied in place and keeping the forms and all exposed surfaces of the concrete continually and visibly wet for the duration of the curing period.

#### B. MEMBRANE CURING

Membrane-curing compound may be used in lieu of water curing on Class B concrete and on concrete which will not be covered later with mortar, liquid hardener, or additional concrete. Except as modified herein, membrane-curing compounds shall be applied in

strict accordance with the manufacturer's recommendations. Membrane-curing compounds shall conform to the requirements of Part 2.04, Membrane Curing Compound, of this specification section.

Membrane-curing compound shall be spray applied in two separate coats, each having a surface coverage of not more than 300 square feet per gallon.

Unformed surfaces shall be covered with curing compound within 30 minutes after final finishing. If forms are removed before the end of the specified curing period, curing compound shall be immediately applied to the formed surface before they dry out.

Curing compound shall be suitably protected against abrasion during the curing period. Whenever the membrane will be subject to damage from traffic or other cause, it shall be protected after drying for 24 hours by a layer of sand or fine earth not less than one inch thick or by other means acceptable to the ENGINEER.

Compound applied improperly or compound applied without sufficient dye to produce a distinguishing color shall be reapplied to the satisfaction of the ENGINEER.

### C. FILM CURING

Film curing with polyethylene sheeting may be used in lieu of water curing on concrete which will be covered later with mortar or additional concrete or will otherwise be covered or hidden from view.

Film curing shall begin as quickly as possible after initial set of the concrete. Polyethylene sheeting shall completely cover the surfaces. Sheeting shall overlap the edges sufficiently for proper sealing and anchorage. Joints between sheets shall be overlapped a minimum of 12 inches and sealed. All tears, holes and other damage shall be promptly repaired.

Covering shall be anchored continuously at edges and shall be anchored on the surface as necessary to prevent billowing.

## 3.08 CONSTRUCTION JOINTS

Construction joints shall be made only at locations indicated on the Drawings or specified herein. Construction joints shall not be made at other locations without the concurrence of the ENGINEER. No vertical construction joints shall be used in walls unless specifically approved by the ENGINEER. The work shall be laid out and conducted so as to minimize the number of construction joints.

All construction joints shall be keyed. Keys shall be continuous and shall have a width equal to 1/3 of the thickness of the wall and a depth equal to 1/6 of the thickness of the wall. Unless indicated otherwise on the Drawings no keys smaller than 3 inches in width and 1-1/2 inches in depth shall be used.

Waterstops of the type specified shall be installed where indicated on the Drawings and in all construction joints in concrete walls and slabs having one face exposed in a dry pit or room and having the other face in contact with backfill, sub grade, groundwater, or other liquid.

A jet of air and water shall be applied to the surface of horizontal construction joints to remove all laitance when the concrete has set sufficiently for the jet to expose the coarse aggregate without loosening same. Immediately prior to placing another lift, the surface shall be thoroughly cleaned and washed by water jet followed by air jet to remove standing water. The surface of the concrete shall then be covered by a uniform, evenly distributed layer of cement-sand mortar to a thickness of 1 inch. The cement-sand mortar shall be composed of a mixture of 1.3 parts by volume Portland Cement and 1 part by volume fine aggregate and shall have a water-to-cement ratio equal to that of the concrete to follow.

### **3.09 EXPANSION JOINTS**

Expansion joints shall be provided as shown on the Drawings. Details of the expansion joints and materials of construction shall be as shown on the Drawings and specified in these Contract Documents. If not shown on the Drawings, expansion joints shall consist of full-depth, preformed, 1/2-inch asphalt plank material conforming to ASTM D 994.

### **3.10 BONDING NEW CONCRETE TO EXISTING CONCRETE**

Where new concrete is to be cast against and permanently bonded to an existing concrete surface, the existing concrete shall be chipped or cut back from the surface a minimum distance of 1-1/2 inches or as necessary to expose sound concrete, remove loose or weathered concrete and provide a roughened surface for bonding to the new concrete. Edges shall be cut square and feathered edges will not be permitted. All loose material remaining after chipping or cutting operations shall be removed by sandblasting and/or stiff wire brushing.

Where chipping back of existing concrete is not possible and where approved by the ENGINEER, the surface of existing concrete may be prepared by sandblasting or acid etching. If sandblasting or etching is used, the surface of the existing concrete shall be bare, clean, dry, and structurally sound. All grease, oil, wax, or other residue shall be removed by scraping followed by washing with a nonionic detergent or a suitable solvent compatible with the epoxy bonding agent to be used. Animal fats may be removed by scrubbing with a 10 percent solution of caustic soda to saponify them.

After all loose material, grease, etc., have been removed, the surface of the existing concrete shall be etched by either sandblasting or scrubbing with a 10-20 percent solution of hydrochloric acid in water applied at a rate of 1 quart per square yard followed by a thorough rinsing with clean water. The surface shall then be allowed to dry completely before application of the epoxy bonding agent. Goggles, rubber boots, and rubber gloves shall be worn by workmen when applying caustic soda or acids.

When the surface is dry and just prior to placing the new concrete, an epoxy bonding agent shall be applied to the surface of the existing concrete with a whitewash brush or stiff broom. The epoxy bonding agent shall be spread evenly over the surface to be bonded, avoiding skips and holidays, to wet film thickness of 40 to 60 mils. The new concrete shall be placed as soon as the epoxy bonding agent becomes tacky. In the event that the epoxy bonding agent is allowed to dry before placement of the new concrete, the surface shall be recoated with epoxy.

The epoxy bonding agent shall comply with the material requirements of Part 2.06, Epoxy Bonding Agents, of this specification section and shall be applied in strict conformance to the manufacturer's recommendations. Adequate safety precautions shall be taken during the handling and use of the epoxy bonding agent.

### 3.11 EMBEDDED ITEMS

Wherever steel, wrought or cast iron piping, fittings, valves, collars, sleeves, structural steel, electrical conduits, appurtenances and fixtures, equipment, anchorages or castings are shown for embedment in the concrete, such items must be on hand before concrete is poured. They shall be set in place accurately and firmly braced before concrete is poured around them. No cutouts for future installation of these items shall be permitted.

Before placing concrete, the CONTRACTOR shall see that all embedded parts are accurately positioned and firmly and securely fastened in place. They shall be thoroughly clean and free from any coating, rust, scale, oil or other foreign matter. The embedding of wood in concrete shall be avoided whenever possible. If wood is to be embedded, it shall be thoroughly wetted before the concrete is placed. After placement, surfaces not in contact with concrete shall be cleaned of concrete spatter and other foreign substances.

Conduit shall be installed between the reinforcing steel in walls or slabs which have reinforcement in both faces. In slabs which have only a single layer of reinforcing steel, conduit shall be placed under the reinforcement.

Unless installed in pipe sleeves, anchor bolts shall have sufficient threads to permit a nut and washer to be installed on the concrete side of the form or template. A second nut and washer shall be installed on the other side of the form or template and the two nuts shall be adjusted so that the bolt will be held rigidly in proper position.

The CONTRACTOR shall be responsible for coordinating all work and ensuring that all embedded items or openings to be built into the concrete are placed in the forms before concrete is placed. The contractor shall be responsible for conferring with his subcontractors and suppliers regarding their requirements for embedments and openings.

Forms, sleeves, and inserts shall be set, and concrete shall be cast to the lines and grades indicated on the Drawings and as detailed in these Contract Documents. The maximum deviation from true line and grade shall not exceed the tolerance listed below. Deviation in alignment of slabs or wall shall not exceed a rate of 1/8 inch in 10 feet within the tolerances specified.

ITEM	MAXIMUM TOLERANCE
Sleeves and inserts	+1/8" -1/8"
Project ends of anchor bolts	+1/4" -0.0"
Anchor bolt setting	+1/16" -1/16"
Concrete forms	+1/8" -1/8"

All slabs shall be carefully finished true to grade such that the surface is free draining and contains no depressions which can hold or collect water.

Regardless of the tolerances listed herein, it shall be the responsibility of the CONTRACTOR to limit deviations in line and grade to tolerance which will permit proper installation and operation of mechanical equipment and piping.

### **3.12 WATER TIGHTNESS**

It is the intention of this specification section to provide impervious concrete. All pits below groundwater level and all structures for holding or carrying water shall be watertight. A loss of not more than 1/4 inch depth in 24 hours will be permitted when water-holding structures are filled. All exposed surfaces of water-holding structures and interior surfaces of pits below groundwater level shall be free from visible damp spots or seepage before acceptance. Repeated tests and repairs may be required by the ENGINEER to obtain watertight structures. All structure shall be drained at the completion of tests unless otherwise directed by the ENGINEER. The cost and expense of all testing for water tightness and of providing a watertight structure shall be borne by the CONTRACTOR. Methods of repair shall be acceptable to the ENGINEER.

The use of special admixtures or integral waterproofing compounds in concrete required to be watertight is not required but may be permitted, provided the materials and methods are approved in writing by the ENGINEER.

### **3.13 CONCRETE EMBEDMENT AND ENCASEMENT OF PIPE**

Concrete for embedment and encasement shall be installed where and as indicated on the Drawings and at such locations where installation conditions require such pipe reinforcement because of unforeseen conditions encountered in the work, as determined by the ENGINEER.

Embedment and encasement of pipe shall be preceded by the following preliminary steps:

- A. All loose material shall be removed from the trench prior to placing concrete. All concrete shall have a continuous contact with undisturbed soil on sides and bottom of trench.
- B. A base course of concrete shall be accurately screeded to such grade and elevation that the pipe will be at specified grade when pipe bells are supported on, and in contact with, the top surface of such base course.
- C. Each length of pipe shall be rigidly held in alignment and anchored, to prevent flotation, in a manner acceptable to the ENGINEER.

### **3.14 PILE DRIVING AND CONCRETE WORK**

The Contractor shall not drive foundation piling which may damage freshly placed or existing concrete structures. Minimum distance between concrete less than seven days old and pile driving operations shall be 100 feet. Any damage made to concrete structures from pile driving operations shall be repaired by the Contractor at his expense.

### **3.15 DEFECTIVE WORK AND METHODS OF REPAIR**

All defective or damaged work shall be removed and replaced or repaired as directed by the ENGINEER. Any work which has not been constructed in accordance with these Contract Documents shall be considered defective. No defective or damaged work shall be patched, repaired or covered without prior inspection and approval of the ENGINEER.

Defects in formed concrete surfaces shall be repaired within 24 hours of placement, to the satisfaction of the ENGINEER, and defective concrete shall be replaced within 48 hours after the adjacent forms have been removed. All concrete which is honeycombed or otherwise defective shall be cut out and removed to sound concrete, with edges square cut to avoid feathering.

Except as modified herein, concrete repair work shall conform to Chapter 9 of ACI 301 and shall be performed in a manner that will not interfere with thorough curing of surrounding concrete. All repair work shall be adequately cured.

Where authorized by the ENGINEER, repair may be accomplished by patching conducted as specified herein. However, permission to patch shall not waive the ENGINEER's right to have the defective work completely removed if the patch or repairs do not, in the ENGINEER's opinion, satisfactorily restore the quality and appearance of the work. Patching shall be conducted as follows:

- A. Chip away defective areas at least 1-1/2 inches deep perpendicular to the surface, wet the area and 6 inches around it to prevent absorption of water from patching mortar, and brush a sand-cement grout consisting of one part fine aggregate to one part Portland Cement into the surface, following with patching mortar.
- B. Patching mortar shall be no richer than one part Portland Cement to three parts fine aggregate using white Portland Cement to replace a portion of the gray cement as determined by a trial patch and shall contain only the minimum mixing water required for placing. Re-temper the mortar if necessary without the addition of water by allowing it to stand for one hour during which time it shall be mixed with a trowel to prevent setting.
- C. Mortar shall be compacted into place and screeded to leave the patch higher than the surrounding surface, then left undisturbed for one or two hours to permit initial shrinkage before being finally finished to match the adjoining surface. Cure patch in accordance with the requirements of Part 3.07, Curing, of this specification section.

### **3.16 LOADS APPLIED TO NEW CONCRETE**

Loads including, but not limited to, earth loads, loads exerted from bracing or shoring, wind loads, hydrostatic or hydraulic loads, equipment or vehicle loads, or loads exerted by stacked materials, shall not be permitted until the concrete has reached its specified 28-day strength.

Concrete which has cracked due to overloading, loading before required strength has developed, or otherwise damaged shall be repaired or replaced as determined by the ENGINEER.

END OF SECTION