INFRASTRUCTURE DESIGN STANDARDS

GENERAL SPECIFICATIONS 11
CONCRETE

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THE CITY OF NEW YORK
BUREAU OF WATER AND SEWER OPERATIONS
DEPARTMENT OF ENVIRONMENTAL OPERATIONS

GENERAL SPECIFICATION 11 - CONCRETE

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GENERAL SPECIFICATION 11 - CONCRETE

CHAPTER 1 - GENERAL

1.1 Scope

1.1.1 This specification covers cast-in-place structural concrete for use in buildings and structures, paving concrete (except heavy duty paving concrete), precast, and miscellaneous cast-in-place concrete except as noted in 1.1.2. The following chapters are contained within this specification:

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1.1.2 The following subjects are considered outside the scope of these specifications.

(1) Thin section precast concrete construction (including architectural wall panels) and precast floor and roof units or precast wall or column sections.

(2) Heavy weight shielding concrete

(3) Heavy duty paving concrete (high density concrete or latex modified concrete toppings).

(4) Terrazzo

(5) Insulating concrete

(6) Refractory concrete

(7) Composite construction

(8) Gunned Applications (Shotcrete, Gunite, etc.)

(9) Intrusion grouting (Prepack Concrete)

1.2 Submittals

1.2.1 General

Submittals required within the following sections by this standard specification shall be submitted for review unless specifically stated for acceptance, in which case the submittal shall be approved by the Engineer. A basic list of required submittals will be found at the beginning of each chapter.

All material, equipment, and aggregate approved by the Materials Bureau of the New York State Department of Transportation (NYSDOT), in the NYSDOT publications:

M.A.P. Code 7.42-3.1 Approved materials and equipment for use on NYSDOT Projects, October 1989.

M.A.P. Code 7.42-3.2 Approved sources of fine and coarse aggregates, February 1989.

respectively, are acceptable for use without a detailed submission. Submittal is required stating the particular material, equipment or aggregate sources to be used with approval identification number, and/or page number.

1.2.2 Test and Inspection Reports

Testing agencies shall report the results of all tests and inspections performed during the course of the work to the Supervising Engineer for Concrete Construction on a form satisfactory to the Department.

1.3 Loading and Support of Concrete

Construction loads shall not exceed the superimposed load which the member, with necessary supplemental support, is capable of carrying safely and without damage. The amount and method of distributing the loads and the proposed supplemental supports during construction shall be acceptable at all times to the Engineer.

1.4 Definitions

1.4.1 The following terms are defined for general use in these specifications:

1.4.1.1 (Project) "Detailed Specification - Concrete" - Any individual specification which employs the "General Specification - Concrete" whether attached or by reference, which serves as the instrument for making the mandatory and optional selections required under this specification and for specifying items not covered herein.

1.4.1.2 Project drawings - The "Contract Drawings" as defined in Article 2 of the Agreement.

1.4.1.3 Architect/Engineer - The "Engineer" or "Architect" as defined in Article 2 of the Agreement.

1.4.1.4 Acceptable, Approved, Permitted, Requested or Submitted - Reference in these specifications to any of these terms shall mean acceptable to, approved by, permitted by, requested by or submitted to the Supervising Engineer for Concrete Construction.

1.4.1.5 Department - that Department or Agency with whom the Contractor has contracted to perform the work and as further defined in Article 2 of the Agreement.

1.4.1.6 Supervising Engineer for Concrete Construction - The Professional Engineer designated by the Commissioner and acceptable to the Architect/ Engineer (on Building Department Form 10A) to be responsible for supervision of the Concrete work performed by the Contractor. The Supervising Engineer for Concrete Construction may or may not be the Resident Engineer (see Article 2 of the Agreement). The Supervising Engineer for Concrete Construction will, in all cases, assume the responsibilities outlined in Section 27-132 (a) Controlled Inspection of the New York Building Code. The Supervising Engineer for Concrete Construction will also be responsible for filing with the Building Department (or other Regulatory Agency) all required forms, test results, reports and all such other documents as may be required by that Department or Agency. It is the intent of the Department that all aspects of the Concrete work performed by the Contractor be channeled through the Supervising Engineer for Concrete Construction. Unless otherwise approved by the Department, the Supervising Engineer for Concrete Construction will maintain his office and all records at the job site. It will be his responsibility to determine the proper distribution of all paper work relating to the Concrete work performed by the Contractor so as to keep the Resident Engineer, the Consultant, Architect/Engineer, the Borough Office if any, and the Commissioner's Office informed of the progress of the work. Where so designated in the Detailed Specification, the Supervising Engineer for Concrete Construction will also be responsible for the testing and inspection required by Section 27-132 (b) Semicontrolled Inspection, of the New York City Building Code. If the Detailed Specifications do not specifically state that the Supervising Engineer for Concrete Construction will also perform the required Semicontrolled Inspection, then these requirements (Section C27-132 (b) New York City Building Code) remain the responsibility of the person "superintending the use of the material or its incorporation into the work," namely the Contractor.

1.4.1.7 Required - The term "required" shall mean required by the (project) detailed specification and/or drawings or this specification.

1.4.1.8 Lightweight concrete - Concrete intentionally made to have low density by use of lightweight aggregate or a mixture of lightweight and normal weight aggregate, and usually required to have an air-dry unit weight less than 115 lb per cubic feet.

1.4.1.9 Normal weight concrete - Concrete for which density is not a controlling attribute, made with aggregates of types covered by ASTM C33, and usually having unit weights in the range of 135 to 160 lb per cu ft.

1.4.2 The following items as defined in the New York City Building Code Section 27-132 are reproduced below.

§27-132 Inspection Requirements - The following requirements shall apply to the inspection of all materials which, in their use, are regulated by the provisions of this code:

(a) Controlled Inspection. - All such materials which are designated for "controlled inspection" under the provisions of this code shall be inspected and/or tested to verify compliance with code requirements. Unless otherwise specifically provided by code provisions, all required inspections and tests of materials designated for "controlled inspection" shall be made and witnessed by or under the direct supervision of an architect or engineer retained by or on behalf of the owner or lessee, who shall be, or shall be acceptable to, the architect or engineer who prepared or supervised the preparation of the plans, and the architect or engineer by whom, or under whose direct supervision, the required inspections and test are made and witnessed shall file with the department signed copies of all required inspection and tests reports, together with his signed statement that the material and its use or incorporation into the work comply with the code requirements, unless the filing of such reports and statement is specifically waived by code provisions. The provisions of Section 27-195 of article nineteen of this subchapter relating to notice of commencement of work shall be complied with prior to the commencement of any work requiring controlled inspection.

(b) Semicontrolled Inspection. - All materials that are not designated for controlled inspection under the provisions of this code shall be subjected to semicontrolled inspection and, as such, shall be inspected and/or tested to verify compliance with code requirements by the person superintending the use of the material or its incorporation into the work, except that all required inspections and tests may, at the option of the owner or lessee, be made and witnessed by or under the direct supervision of any architect or engineer retained by or on behalf of the owner or lessee, who shall be, or shall be acceptable to, the architect or engineer who prepared or supervised the preparation of the plans. The person superintending the use of the material or its incorporation into the work, or the architect or engineer by or under whose direct supervision the required inspections and tests are made and witnessed, as the case may be, shall file with the department signed copies of all required inspection and test reports, together with his signed statement that the material and its use or incorporation into the work comply with code requirements, unless the filing of such reports and statement is specifically waived by code provisions.

(c) Off-site Inspection. - In all cases where code provisions require that the inspection and/or test of materials be made off-site, or prior to actual use or incorporation into the work,

the inspection shall mark or cause to be marked for identification all units (or packages of units) of the material inspected, and the reported results of such inspection shall state that the material was so marked for identification.

1.4.3 The requirements of the New York City Building Code for controlled concrete are outlined in §27-607 reproduced below.

§27-607 - On Site Inspection. - Inspection of concrete and construction shall conform to the requirements of Tables 10-1 and 10-2 and the provisions of this article.

(a) Controlled Inspection - Controlled inspection of concrete construction shall include:

(1) Strength Tests. - Strength tests shall be performed on all structural concrete. The provisions of reference standard RS 10-3 shall apply. Test cylinders shall be made and stored on the job site in an insulated curing box of sufficient size and strength to contain the required number of cylinders and to minimize the hazard of disturbance during curing. The box shall be heated as required to maintain proper curing conditions. Such box shall be located in an area free from vibration such as pile driving and traffic of all kinds. No concrete requiring inspection shall be delivered to the site until such storage curing box has been provided. Cylinders shall remain in the curing box until ready for delivery to the testing laboratory, but not less than 24 hours. Actual preparation and testing of the cylinders shall be performed by or under the continuing and direct supervision of the architect or engineer designated for controlled inspection and all concrete failing to meet the specified minimum strength requirements shall be rejected by said architect or engineer pending verification of the adequacy of the construction as described in section 27-598 of article three of this subchapter.

(2) Additional Tests. - Each sample recovered for the purpose of strength tests shall be additionally checked by or under the continuing and direct supervision of the architect or engineer designated for controlled inspection for slump, air content, unit weight, and temperature in accordance with the standard procedures noted in reference standards RS 10-3.

(3) Forms, Reinforcement and Placing. - The size and dimensions of the concrete members formed by the concrete forms, size and positions of reinforcement in place, and the placement of concrete, including temperatures, protections against excessive temperatures, curing, the erection and connection of precast members, the amount of water added in the field, and tensioning of all prestressed elements shall be recorded and compliance with the provisions of this code shall be attested by the architect or engineer designated for controlled inspection.

(b) Other required inspection. - Quality control or inspection shall be provided with respect to all operations of mixing and placing concrete and reinforcement that are not designated for controlled inspection. Such inspection shall be provided in sufficient scope to assure conformance of such operations with the requirements of this section (and of the cited reference standards) and attestation of such conformance shall be executed by the person superintending the use of the material in accordance with the requirements of Subdivision (b) of section 27-132 of Article seven of subchapter one of this chapter.

TABLE 10-1 INSPECTION OF MATERIALS AND ASSEMBLIES

Materials	Elements That Shall be Subject to Controlled Inspection	Elements That Are Not Subject to Controlled Inspection
Concrete	Materials for all structural elements proportioned on the basis of calculated stresses 70 percent or greater, of basic allowable values. See Article 5 for specific requirements relating to "quality control of materials and batching."	(1) All material for structural elements proportioned on the basis of calculated stresses less than 70 percent of basic allowable values. (2) Concrete materials for: (a) Short span floor and roof construction proportioned as per section 27-610. (b) Wall and footings for buildings in occupancy group J-3. (3) Metal reinforcement. All structural elements and connections.

TABLE 10-2 INSPECTION OF METHODS OF CONSTRUCTION

Materials	Operations on Structural Elements That Shall Be Subject to Controlled Inspection	Operations on Structural Elements That Are Not Subject to Controlled Inspection
Concrete	Except for those operations specifically designated in this table as not subject to controlled inspection, for all concrete, the operations described in section 27-607 shall be subject to controlled inspection	(1) All operations relating to the construction of members and assemblies (other than prestressed members) which involve the placement of a total of less than 50 cubic yards of concrete and wherein said concrete is used at levels of calculated stress 70 percent or less of basic allowable values. (2) Placing and curing of concrete for all: (a) Short span floor and roof construction as per section 27-610. (b) Walls and footings for buildings in occupancy group J-3. (3) Size and location of reinforcement for walls and footings for building in occupancy group J-3. (4) All other operations not described in subdivision (a) of 27-607.

1.4.4 Other words and terms used in these specification are defined in Cement and Concrete Terminology (ACI 116R, which is also ACI SP-19).

1.5 ASTM Standards
American Society for Testing and Materials
1916 Race Street
Philadelphia, Pennsylvania 19103

The standards for the American Society for Testing and Materials referred to in these specifications are listed below with their serial designation and are declared to be a part of these specifications, the same as if fully set forth herein. The revision of these documents in effect on the date of bid request shall be applicable:

A 82 Standard Specification for Steel Wire, Plain, for Concrete Reinforcement

A 184 Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement

A 185 Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement

A 416 Standard Specification for Uncoated Seven-Wire Stress-Relieved Steel Strand for Prestressed Concrete

A 421 Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete

A 496 Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement

A 497 Standard Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement

A 615 Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

A 616 Standard Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement

A 617 Standard Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement

A 706 Standard Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement

A 722 Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete

A 767 Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement

A 775 Standard Specification for Epoxy-Coated Reinforcing Steel Bars

A 884 Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement

C 31 Standard Method of Making and Curing Concrete Test Specimens in the Field

C 33 Standard Specification for Concrete Aggregates

C 39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

C 42 Standard Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

C 94 Standard Specification for Ready-Mixed Concrete

C 109 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)

C 138 Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete

C 143 Standard Test Method for Slump of Portland Cement Concrete

C 144 Standard Specification for Aggregate for Masonry Mortar

C 150 Standard Specification for Portland Cement

C 171 Standard Specification for Sheet Materials for Curing Concrete

C 172 Standard Method of Sampling Freshly Mixed Concrete

C 173 Standard Test Method of Air Content of Freshly Mixed Concrete by the Volumetric Method

C 192 Standard Method of Making and Curing Concrete Test Specimens in the Laboratory

C 231 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

C 260 Standard Specification for Air-Entraining Admixtures for Concrete

C 309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

C 330 Standard Specification for Lightweight Aggregates for Structural Concrete

C 387 Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete

C 494 Standard Specification for Chemical Admixtures for Concrete

C 567 Standard Test Method for Unit Weight of Structural Lightweight Concrete

C 595 Standard Specification for Blended Hydraulic Cements

C 618 Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete

C 685 Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing

C 803 Standard Test Method for Penetration Resistance of Hardened Concrete

C 805 Standard Test Method for Rebound Number of Hardened Concrete

C 873 Standard Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds

C 881 Standard Specification for Epoxy-Resin-Base Bonding System for Concrete

C 900 Standard Test Method for Pullout Strength of Hardened Concrete

C 989 Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

C 1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete

C 1059 Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete

C 1064 Test Methods for Temperature of freshly Mixed Portland Cement Concrete

C 1077 Standard Practice for Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

D 98 Standard Specification for Calcium Chloride

D 994 Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)

D 1751 Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (nonextruding and Resilient Bituminous Types)

D 1752 Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

E 329 Standard Recommended Practice for Inspection and Testing Agencies for Concrete, Steel, and Bituminous Materials as Used in Construction

1.6 Other Reference Standards and Publications

The following standards and publications are referred to in these specifications.

1.6.1 American Concrete Institute (ACI)
P.O. Box 19150
Detroit, MI 48219:

SP-15(89)	Field Reference Manual: Specifications for Structural Concrete for Buildings ACI 301-89 with selected ACI and ASTM references.
ACI 116R-85 (SP-19)	Cement and Concrete Terminology
ACI 304R-85	Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R-77(82)	Hot Weather Concreting
ACI 306R-88	Cold Weather Concreting
ACI 309R-87	Guide for Consolidation of Concrete

ACI SP(66)(88)	ACI Detailing Manual
ACI 318-83	Building Code Requirements for Reinforced Concrete
ACI 347-78(84)	Recommended Practice for Concrete Formwork

1.6.2 American Welding Society (AWS), 550 N.W. LeJeune Road, P.O. Box 351040, Miami, FL 33135: "Structural Welding Code - Reinforcing Steel" (AWS D1.4-79).

1.6.3 Concrete Plant Manufacturers Bureau (CPMB), 900 Spring Street, Silver Spring, MD 20910: "Concrete Plant Mixer Standards of the Plant Mixer Manufacturers Division," 1983.

1.6.4 National Ready Mixed Concrete Association (NRMCA), 900 Spring Street, Silver Spring, MD 20910: Check List for Certification of Ready Mixed Concrete Production Facilities," 1984.

1.6.5 American Association of State Highway and Transportation Officials (AASHTO), 444 North Capital Street, N.W., Suite 225, Washington DC 20001: "Standard Method of Test for Sampling and Testing for Total Chloride Ion in Concrete" (AASHTO T260-84).

1.6.6 Concrete Reinforcing Steel Institute (CRSI), 933 North Plum Grove Road, Schaumburg, IL 60195; Manual of Standard Practice, 1986.

1.6.7 Corps of Engineers, U.S. Army Waterways Experiment Station, Vicksburg, MS, Specifications for Rubber Water Stops CRD-C513-74.

1.6.8 Corps of Engineers Specifications for Polyvinylchloride Water Stop CRD-572-74.

1.6.9 Corps of Engineers Specification for Non-Shrink Grout CRD-C621-80.

1.7 Field References

The contractor shall supply to the Resident Engineer a copy of the latest edition of all publications in this list. ACI PUBLICATION SP-15 "FIELD REFERENCE MANUAL" AND "ACI MANUAL OF CONCRETE INSPECTION" TOGETHER CONTAIN THE ENTIRE LIST EXCEPT THOSE ITEMS MARKED WITH AN ASTERISK (*).

ACI 214	Recommended Practice for Evaluation of Compression Test Results of Field Concrete
ACI 306R	Cold Weather Concreting
ACI 347	Recommended Practice for Concrete Formwork
ACI 305R	Hot Weather Concreting
ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 309.1R	Behavior of Fresh Concrete During Vibration
ASTM C 31	Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field

ASTM C 94	Specifications for Ready-Mixed Concrete
ASTM C 138	Method of Test for Slump of Portland Cement Concrete
ASTM C 172	Method of Sampling Fresh Concrete
ASTM C 173	Method of Test for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 231	Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 470	Specification for Single-Use Molds for Forming 6x12 in Concrete Compression Test Cylinders
*N.Y.C. BLDG. CODE	Latest Edition, including a copy of Reference Standard RS10-3 (ACI 318 Building Code Requirements for Reinforced Concrete and the Commentary thereto).
*CRSI	Recommended Practice for Placing Reinforcing Bars
*CRSI	Recommended Practice for Placing Bar Supports, Specifications and Nomenclature 1965

1.8 Quality Assurance

1.8.1 General

Concrete materials and operations will be inspected by the Supervising Engineer for Concrete Construction as the work progresses. Failure to detect defective work or material shall not prevent rejection later when a defect is discovered nor shall it obligate the Engineer for final acceptance.

1.8.2 Testing Agencies

Testing agencies that perform testing services on concrete materials shall meet the requirements of ASTM C 1077. Testing agencies that perform testing services on reinforcing steel shall meet the requirements of ASTM E329. The testing agency performing the testing shall be acceptable to the Owner prior to performing any work. Tests of concrete required in Chapter 16 shall be made by an ACI Concrete Field Testing Technician Grade 1 or equivalent. Equivalent certification programs shall include requirements for written and performance examinations as stipulated in ACI publication CP1.

1.8.3 Responsibilities of the Testing Agency

Responsibilities of the Testing Agency are provided in Chapter 16.

END OF CHAPTER

CHAPTER 2 - MATERIALS

2.1 General

This section covers the requirements for cement, admixtures, water, and aggregates.

2.2 Submittals

2.2.1 Information on types, classes, procedures, names and plant locations for cementitious materials; types, pit or quarry locations, producers' names, gradations and properties required by ASTM C33 for aggregates; types, brand names, producers' names for admixtures; and source of supply for water and ice.

2.2.2 Except for admixtures and water, test results not more than 90 days old confirming conformance with applicable specifications.

2.2.3 If it is necessary to use retarding or accelerating admixture in mass concrete, submit data on the admixture proposed.

2.3 Cement

2.3.1 Cement shall conform to ASTM C150. Blended hydraulic cements shall conform to ASTM C595, except that Types S and SA shall not be used.

2.3.2 Unless otherwise specified, cement shall be Type II, ASTM C150.

2.3.3 The cement used in the work shall correspond to the cement used when selecting concrete proportions.

2.4 Admixtures

2.4.1 Admixtures to be used in concrete, when required or permitted, shall conform to the following appropriate specifications:

2.4.1.1 Air-entraining admixtures, ASTM C260

2.4.1.2 Water-reducing, retarding, and accelerating admixtures, ASTM C494

2.4.1.3 Pozzolanic admixtures, ASTM C618

2.4.1.4 Blast furnace slag, ASTM C989

2.4.1.5 All mixes shall include a water reducing agent.

2.4.2 Admixtures used in the work shall be of the same composition as those used in establishing the concrete proportions.

2.5 Water

Mixing water for concrete and water used for ice in concrete shall be drawn from New York City mains. Water shall meet the requirements of ASTM C94.

2.6 Aggregates

2.6.1 General

2.6.1.1 (a) Combined gradation shall be used unless specified.

(b) Aggregate gradations shall be judged based upon the combined gradation and particle distribution in the mixture of coarse and fine aggregates.

(1) Unless otherwise specified, the gradation shall conform to the nominal 3/4 in. size.

(2) Aggregate - Unless otherwise specified or permitted, aggregates shall conform to ASTM C33 and the following optional requirements:

(a) The nominal maximum aggregate size shall comply with 2.6.1.1.(b)(1) - Size of Coarse Aggregate.

(b) The combined aggregates shall be well graded from coarsest to the finest with not more than 18% nor less than 8% retained on each individual sieve between the coarsest size and the No. 50 sieve and the nominal maximum aggregate size sieve. The No. 100 and finer sieves shall have less than 8% retained.

(c) Aggregates used in concrete shall be obtained from the same sources in accordance with ASTM E11.

(3) Where ½ in. and 3/8 in. nominal maximum aggregate sizes are required, comply with gradation limits in Table 2, ASTM C 33 and provide a uniformly graded mixture subject to the approval of the Engineer.

(c) Aggregate shall be proportioned by weight and controlled to avoid segregation during delivery. Aggregate of 1-1/2 in. nominal size shall be blended using a minimum of three sizes.

(d) If gradations vary during progress of the work, adjust proportions to reproduce a combined gradation similar to that in the mix submittal.

(e) The gradations shall be plotted and submitted on:

(1) A combined grading chart (percent passing versus sieve size) on which the limits noted above shall be plotted.

(2) An aggregate Particle Distribution Chart (percent retained versus sieve size).

(f) The fineness modulus of the combined aggregates as well as the fineness modulus of the individual ingredients (blended stone and sand) shall be computed and reported.

2.6.1.2 The following parameters for the combined aggregates shall be computed and reported as percent of combined aggregates:

(a) The large particles (identified by the letter "Q") defined as that portion retained by the No. 8 and above sizes.

(b) The intermediate particles (identified by the letter "I") defined as that portion passing the 3/8 inch sieve but retained on the No. 8 sieve.

(c) The fine particles (identified by the letter "W") defined as that portion passing the No. 8 sieve.

(d) For mixes which have in excess of 564 lb of cementitious material, the excess over the 564 lb shall be added to the W factor to obtain an adjusted factor "W-ADJ." Similarly, any amount less than 564 lb shall be subtracted from the "W" factor to obtain "W-ADJ."

(e) The coarseness factor as a percentage is defined by the formula

C.F. = [Q/(Q+I)] x 100

(f) The workability factor defined as equal to "W-ADJ."

(g) All the above factors (Q, I, W, and W-ADJ) shall be computed volumetrically as percentages of combined aggregates.

2.6.1.3 For the coarseness factors indicated, the workability factor shall be kept within the limits shown in the following table. Intermediate values shall be interpolated.

C.F.(%)	W-ADJ(%)
0	41
10	41
20	41
40	38
60	35
80	32
90	32
100	32

2.6.1.4 In addition, the percentage of mortar in the mix (as designed and as produced) shall be kept within the limits noted below. Mortar consists of fine sand (minus No. 8 sieve) and the paste (cementitious material, air, and water). The percentage of mortar shall be computed and reported for the mix as designed and as produced.

(a) For General Use - 55.5% to 57.0% mortar, preferably on the low side.

(b) Special mixes for small pumps and 2-in.-diameter pump lines and 1/2 in. coarse aggregate require:

Crushed stone aggregate = 60.0%

(c) Pea gravel mixes for placement in thin toppings (1-1/2 in. thick or less) may need as much as 63-64% mortar.

2.6.2 Aggregates for lightweight concrete shall conform to "Specifications for Lightweight Aggregates for Structural Concrete" (ASTM C330). Unless otherwise specified the size shall be 3/4 inch to No. 4. Fine aggregate conforming to ASTM C33 may be used providing the weight and strength requirements are met.

2.6.3 Bank Run Gravel, unwashed sand, gravel or stone aggregates or previously prepared mixtures of fine and coarse aggregates will not be permitted for use.

2.6.4 Granite or Siliceous gravel shall not be used for structural steel fireproofing in buildings.

2.6.5 Aggregates used in concrete shall be obtained from the sources and have the same size ranges as the aggregates used in establishing the concrete proportions.

2.7 Storage of Materials

2.7.1 Cement shall be stored in weathertight buildings, bins or silos which will provide protection from dampness and contamination and will minimize warehouse set.

2.7.2 Aggregate stockpiles shall be arranged and used in a manner to avoid excessive segregation or contamination with other materials or with any other sizes of like aggregates. To insure that this condition is met, any test for determining conformance to requirements for cleanliness and grading shall be performed on samples secured from the aggregates at the point of batching. Frozen or partially frozen particles shall not be used.

2.7.3 Stockpiles of natural or manufactured sand shall be allowed to drain freely to minimize variations in moisture content throughout the stockpile.

2.7.4 Unless pre-dampening is not considered desirable by the manufacturer, or is considered impractical by the Supervising Engineer for Concrete Construction, dry lightweight aggregates shall be uniformly predampened as necessary. To prevent excessive variations in moisture content, predampened aggregates shall be allowed to remain in the stockpiles for a minimum of 12 hours before use.

2.7.5 Admixtures shall be stored in such a manner as to avoid contamination, evaporation or damage. For those used in the form of suspensions or nonstable solutions, suitable agitating equipment shall be provided to assure uniform distribution of the ingredients. Liquid admixtures shall be protected from freezing and other temperature changes which would adversely affect their characteristics. All admixture containers shall be clearly marked with paint as to their content and dosage.

2.8 Identification of Materials

2.8.1 All materials used in the manufacture of concrete shall be accompanied by a certificate from the manufacturer or supplier indicating test results of current production stockpiles or shipments.

2.9 Change of Materials

2.9.1 If brand, type, size or source or cementitious materials, aggregates, water, ice, or admixtures is changed, new historical field strength test data or data from new trial mixtures or evidence which indicates that the change will not adversely affect the relevant properties of the concrete shall be submitted for review and acceptance by the Engineer prior to use in concrete.

END OF CHAPTER

NO TEXT ON THIS PAGE

CHAPTER 3 - PROPORTIONING

3.1 General

Concrete for all parts of the work shall be homogeneous and, when hardened, shall have the required strength, resistance to deterioration, durability, resistance to abrasion, water-tightness, appearance and other specified properties.

3.2 Submittals

3.2.1 Mix proportions and characteristics. Mixture proportions conform to the requirements of the NY City Administrative Building Code and this Chapter for cement content, slump, maximum size of coarse aggregate, air content, admixtures, and chloride concentration, as well as compressive strength.

3.2.2 Method and test data used to establish proportions.

3.2.3 Requests for adjustments to mixture proportions.

3.2.4 Requests to adjust mixture proportions necessary for workability or consistence.

3.2.5 If it is desired to decrease the cement content of the concrete mixture to reduce the margin of overstrength after having satisfied the requirements of this Chapter, but not less than that required by the N.Y. City Building Code, a request for acceptance on a trial basis of this proposed revised mixture with a lower cement content is required.

3.2.6 If it is necessary to increase the cement content, a request for acceptance on a trial basis of the proposed revised mixture with a higher cement content is required.

3.2.7 Submit confirmation that adequacy of modified proportions has been verified from a set of new field test data.

3.2.8 Request to use the volumetric batching method.

3.2.9 Requests to exceed the ASTM C94 required time of discharge.

3.3 Strength

The strength of the concrete for each portion of the structure shall be as designated in the "Detailed Specifications" and shall be as listed in the schedule therein. If not otherwise noted in the detailed specifications, strength of concrete for floors shall be in accordance with Section 3.11. Strength requirements shall be based on 28-day compressive strengths, unless high early strength is specified, in which case required strengths shall be obtained at 7 days.

3.4 Weight

Lightweight concrete shall be of the strength designated in the "Detailed Specifications" and shall not weigh more than the air dry unit weight specified therein. The air dry unit weight shall be determined in accordance with ASTM C567. The wet unit weight of the fresh concrete shall be within ± 3 lb of the wet weight of the fresh concrete as determined when establishing the mix proportions to be used, and shall be used together with air determination tests as a basis of control in the field.

3.5 Durability

3.5.1 All normal weight concrete shall contain entrained air as indicated in Table 3.5.1.

TABLE 3.5.1 - Total Air Content for Various Sizes of Coarse Aggregates

Nominal Maximum Size of Coarse Aggregate, Inches	Total Air Content Percent by Volume (±1.5%)
3/8	7.5
½	7.0
3/4	6.0
1	6.0
1 ½	5.5

NOTE: The above limits for air entrainment shall be maintained when coloring agents, fly ash, carbon black, fine sands and related products are used in the concrete mix. If additional quantities of admixture are required to maintain these limits, they shall be added.

3.5.2 Lightweight concrete shall contain 6 percent ± 2 percent total air when the nominal maximum size of coarse aggregate is greater than 3/8 in., or 7 percent ± 2 percent when the nominal size is less than 3/8 in. as determined in accordance with ASTM C173.

3.5.3 Structural concrete of normal weight shall be as indicated in the Detailed Specifications, and have a water-cement ratio not exceeding 0.44.

3.5.4 For concrete that will be exposed to injurious concentrations of sulfate-containing or other chemically aggressive solutions, ASTM C150, Type II cement shall be used, unless Type V cement is specifically required by the Detailed Specifications. For normal weight concrete in such application, the water-cement ratio shall not exceed 0.44 by weight; for lightweight concrete, the proportions shall be selected to produce a specified compressive strength of f'c of at least 4000 psi.

3.5.5 For prestressed concrete and for all concrete in which aluminum or galvanized metal is to be embedded, it shall be demonstrated by test that the mixing water of the concrete, including that contributed by the aggregates and any admixture used, will not contain a deleterious amount of chloride ion in excess of that allowed by 3.8.1.

3.6 Slump

3.6.1 Unless otherwise permitted or specified, the concrete shall be produced at a slump of 4 in. measured at the point of delivery except as noted herein.

3.6.1.1 Monolithic or Precast Pipe - Slump shall be 1 ½ to 3 in.

3.6.1.2 For Mass Concrete, see Table 3.9.2.3 (II).

3.6.1.3 For Floors, see 3.11.2.

3.6.2 A tolerance of up to 1 in. above the maximum indicated shall be allowed for one batch in any five consecutive batches tested. Concrete of lower than usual slump may be used provided it is properly placed and consolidated. The slump shall be determined by ASTM C143.

3.6.3 Slump for concrete for floors shall be in accordance with 3.11.2.

3.6.4 When use of a Type F or G high range water reducing admixture conforming to ASTM C494 is permitted to increase the slump of concrete, proportion the concrete to have a slump of 3 in. (maximum) before the admixture is added, and a slump of 8 in. (maximum) at the point of placement after the admixture is added.

3.7 Maximum Size of Coarse Aggregate

3.7.1 The nominal size of the aggregate shall not be larger than one-fifth of the narrowest dimension between sides of forms, one-third of the depth of slabs, nor three-fourths of the minimum clear distance between reinforcing bars or between bars and forms, whichever is least. In columns the nominal size of the aggregate shall be limited as above, but shall not be larger than two-thirds of the minimum clear distance between bars. ASTM No. 8 stone or gravel and 3/8 to No. 8 lightweight aggregate may be used for concrete work for electric ducts, conduits, fireproofing of steel members and other work for which larger aggregate is unsuitable.

3.7.2 Coarse aggregates in concrete of normal weight may be of one size for all concrete placed in one day when quantities to be placed are too small to permit economical use of more than one mix design. When a single mix design is so used, the nominal size shall be as required for the most critical condition of concreting, in accordance with the requirements of Section 3.7.1.

3.7.3 The nominal maximum size of coarse aggregate in lightweight concrete shall not exceed 3/4 in.

3.8 Admixtures

If specified or permitted, admixtures shall be subject to the following limitations:

3.8.1 Calcium Chloride as a separate admixture is not permitted.

3.8.1.1 The acid-soluble chloride ion concentration (in percent by weight of cement) in hardened concrete at ages 28 to 42 days, before exposure to external sources of chlorides, determined by AASHTO Method T-260, shall not exceed 0.08 for prestressed concrete and 0.20 for all other concrete. Testing to determine compliance with these requirements shall be performed prior to exposure to external sources of chlorides.

3.8.1.2 Admixtures containing chlorides shall not be used where galvanized steel is embedded or used as a permanent form or where aluminum conduit, couplings, or accessories are embedded in the concrete without adequate corrosion protection for the embedded items. Chloride admixtures are also prohibited where sulfate resisting concrete is required, and in all prestressed concrete construction. When admixtures containing chloride are used, they shall be kept in separate solutions and dispensers and introduced into the mixer at such time so as to avoid coming in contact with dry cement and all other air entraining or water reducing admixtures.

3.8.2 For prestressed concrete and for all concrete which will contain embedments of or remain in contact with aluminum or galvanized metal, the limitation of Section 3.8.1.1 shall apply unless protective measures acceptable to the Architect/Engineer are provided.

3.8.3 Air-entraining, water reducing, retarding, accelerating, and other proprietary chemical admixtures shall be in accordance with the recommendations of the manufacturer.

3.8.4 If specified or permitted, any admixture which will act as an accelerator may be used only when the ambient temperature is less than 40°F. This requirement may be waived only with written approval of the Supervising Engineer for Concrete Construction.

3.8.5 If specified or permitted, any admixture which will act as a retarder may be used in the proportions recommended by the manufacturer when the temperature of the concrete as placed exceeds 65°F and the ambient temperature is expected to rise above 75°F. This requirement may be waived only with the written approval of the Supervising Engineer for Concrete Construction.

3.8.6 Integral waterproofing admixtures shall not be used.

3.8.7 Concrete using admixtures must be proportioned in accordance with Section 3.9.

3.9 Proportioning of Ingredients

3.9.1 General

3.9.1.1 The proportioning of ingredients shall be selected to produce the proper placability, durability, slumps, strength and other required properties. Yield of all mixes as designed shall not exceed 27.2 cu.ft./cu.yd.

3.9.1.2 The proportioning of ingredients shall be such as to produce a mixture which will work readily into the corners and angles of the forms and around reinforcement by the methods of placing and consolidation employed on the work, but without permitting the materials to segregate or excessive free water to collect on the surface.

3.9.1.3 For mass concrete, see also Chapter 14.

3.9.1.4 All lightweight concrete shall be air-entrained in accordance with Section 3.5.2.

3.9.2 Concrete (normal or lightweight)

3.9.2.1 The determination of the concrete mix proportion to attain the required strength shall be in accordance with the procedure, as designated by the "Detailed Specifications" in the schedule set forth therein and in 3.9.2.3, 3.9.2.4, or 3.9.2.5, as applicable.

3.9.2.2 Other Agency Concrete (See Section 19.2)

For those portions of the work where the Rules, Regulatory or Standard Specifications of Agencies other than the Building Department govern, the concrete shall be proportioned in accordance with the applicable Code, Rules Regulations or Standards. Concrete shall be proportioned at a slump of 4 in.

3.9.2.3 New York City Building Code Method I - Mixes with minimum cement content. Concrete shall be proportioned at a slump of 4 in. Concrete shall be proportioned to produce a strength of concrete at least 30% higher than the specified strength shown on the plans. In lieu of making preliminary tests, previously accepted mixes in accordance with NYC Building Code 27-65(a)(4) are acceptable.

Method I is not applicable to the following:

(a) Prestressed Concrete.

(b) Concrete designed for compressive strengths in excess of 5000 psi.

(c) Lightweight concrete with natural sands designed for compressive strength above 3500 psi.

(d) Lightweight concrete with lightweight fine aggregate designed for compressive strength above 2000 psi.

(e) Concrete containing admixtures other than those used for entraining air.

3.9.2.4 New York City Building Department Code Method II - Proportioning on the basis of field experience.

A mix design employing the same ingredients proposed for use, and used successfully on a previous project, or projects, may be used provided the following are submitted by a licensed concrete testing laboratory and approved by the Department.

(a) The name and location of the plant from which the concrete will be batched.

(b) The concrete mix design including detailed data and analysis of the ingredients proposed for use as required in Sections 2.1, 2.2 and 2.4.

(c) Reports for at least 50 consecutive tests of 7- and 28-day concrete strength tests of the proposed mix made during the previous twelve(12) months of concrete batched and delivered from the same plant that is to furnish this job. These data shall include an evaluation in accordance with "Recommended Practice for Evaluation of Compression Test Results of Field Concrete" (ACI 214) to determine the average strengths, moving averages and the coefficients of variation.

(d) Reports of compliance tests of fine and coarse aggregates made during the above tests.

(e) When Method II is specified in the "Detailed Specifications" (in Schedule of Mixes, Section 3.2) but the strength test data for determining the job performance of previously used mixes is not available, an interim mix proportioning satisfactory to the Supervising Engineer for concrete construction may be used temporarily. No change in the mix proportions shall be made until paragraph c above has been complied with and the approval of the Testing Agency obtained.

3.9.2.5 New York City Building Code Method III - This method is limited to situations where the total yardage placed does not exceed 50 cu yd and the levels of calculated stress do not exceed 70 percent of the basic allowable stresses.

3.10 Grout and Mortar

3.10.1 Mortar or grout shall be made with Portland cement, sand, water and additives when required. The term "grout" as used in these specifications refers to a thin mortar, fluid enough to be poured. The sand to be used shall be selected to suit the spacing for placement. Where sand is not usable, the grout shall be composed of cement and water only. Gradation of sand and mix proportioning shall be in accordance with the following table for grouts and mortars using natural sands with strength requirements not in excess of f'c = 4000 psi. For higher strength grouts and mortars or those using manufactured sands or other materials, strength shall be established by trial mixes. Water shall be kept to a minimum, the amounts noted being maximum for a grout. Proportioning by volume shall be limited to small quantities mixed at the job site.

3.10.1.1 Gradation, Natural Sand

	Spaces less than one (1) inch	Spaces one (1) inch or more
Passing 3/8		100
4	100	95-100
8	95-100	80-100
16	70-100	50-85
30	40-75	25-60
50	10-35	10-30
100	2-15	2-10
200	-	-

3.10.1.2 Mixing Proportioning

		Non Air Entrained Mortars and Grouts (Maximum 4% entrapped air)		Air Entrained Mortars and Grouts (Air 8% to 10%)	
		Spaces less than one (1) inch	Spaces one (1) inch or more	Spaces less than one (1) inch	Spaces one (1) inch or more
By Weight	Cement (bags)	10.8	10.5	11.3	11.0
	Sand (lb)	2150	2240	1930	1990
	Maximum water(gals)	59.5	57.8	57.5	55.8
	Maximum water (gals per bag)	5.5	5.5	5.1	5.1
By volume	Cement	1	1	1	1
	Sand(dry rodded)	1.85	2.10	1.6	1.7
	Sand(damp & loose)	2.30	2.35	2.0	2.1
	Maximum water (gals per bag)	5.5	5.5	5.1	5.1

3.10.2 Non Shrink Grouts

3.10.2.1 The grouting and/or mortar material shall be an approved ready-to-use mixture requiring only water for use at the job site. The compressive strength of 2 in. cubes shall be 3000 psi at 7 days. The grouting and/or mortar material shall meet the following performance requirements. When mixed to a flow table consistency of 130 ± 5 percent (ASTM C109 except that the reading shall be taken after 5 drops delivered in 3 seconds) the grout shall show complete vertical shrinkage correction in 3 to 7 days when placed in test cylinders 2 in. diameter by 4 in. high, covered immediately with a glass plate held firmly in place. Initial surface of the grout shall be determined by micrometer measurements to the top of the plate and the thickness of the plate gauged to determine the true initial level of the grout. The glass plate shall be removed at 24 hours and subsequent measurements at 3 and 7 days made to the free surface of the grout. The specimens shall be cured in laboratory air during the test period.

3.10.2.2 Non shrink grouts containing additives such as iron or steel particles depending on oxidation to limit shrinkage shall not be used.

3.10.3 Dry Pack

3.10.3.1 Mortar for dry packing (to be packed or tamped in place) shall be made at no slump consistency. When mixing the batch, only enough water should be added to the dry materials to produce a rather stiff mixture, then additions of water may be made in small increments until the desired consistency is secured. Settlement of the mortar can be reduced by delaying its placing.

The mortar should be mixed; then allowed to stand in a mortar box or other container for about two (2) hours. The box or container should be kept covered. When used, the mixture should be of such consistency that when a sample is squeezed in the hand only enough water will come to the surface to moisten the hand.

3.11 Concrete for Floors

3.11.1 These criteria apply only when strength or durability requirements of Sections 3.3 and 3.5 do not necessitate higher strength or cement content.

3.11.2 Concrete for floors shall be 4000 psi unless otherwise specified in the Detailed Specification and Drawings. Slump shall not exceed 4 in.

END OF CHAPTER

CHAPTER 4 - FORMWORK

4.1 General

4.1.1 Additional formwork requirements for architectural concrete are described in Chapter 13 (*Architectural Concrete").

4.1.2 Earth cuts shall not be used as forms for vertical surfaces, unless required or permitted.

4.1.3 Roof Curbs for scuttles, skylights, ventilators, etc. shall, unless otherwise indicated on contract drawings, be constructed of the same concrete as the roof slab and, unless otherwise shown on the drawings or required by the equipment to be mounted thereon, shall be not less than 8 in. high and 6 in. thick. Curbs shall be secured to roof slab with No. 3 reinforcing bars spaced on 12 in. centers and reinforced laterally with 2 hoops formed of No. 4 reinforcing bars unless otherwise shown on contract drawings.

4.1.4 Materials for form faces in contact with the concrete shall meet the following requirements unless otherwise specified in the Contract Documents.

(a) For Rough Form Finish - No form facing material is specified.

(b) For Smooth Form Finish - The form facing material may be plywood, tempered concrete-form grade hardboard, metal, plastic, paper, or other acceptable material capable of producing the desired finish. The form facing material shall produce a smooth, uniform texture on the concrete.

Do not use form facing material with raised grain, torn surfaces, worn edges, patches, dents, or other defects that will impair the texture of the concrete surfaces.

4.1.5 For form accessories that are partially or wholly embedded in concrete, including ties and hangers, use commercially manufactured accessories.

4.2 Submittals

4.2.1 Shop drawings for formwork.

4.2.2 Data on proposed form release agent.

4.2.3 Data on proposed form facing materials.

4.2.4 Shop drawings on experimental surface finishes.

4.2.5 Shop drawings on proposed construction joints not indicated on contract drawings.

4.2.6 Plan of reshoring.

4.2.7 Data on a proposed departure from location or detail of control joints shown on the contract drawings.

4.2.8 Data on proposed form coating material.

4.2.9 Correlation data for alternate methods of determining form removal strength.

4.3 Design of Formwork

4.3.1 The design and engineering of the formwork, as well as its construction, shall be the responsibility of the contractor. Shop drawings for formwork shall be submitted and include the location of all required and proposed construction joints and additional information, and shall be as required by the detailed specifications. Designs of formwork and preparation of formwork drawings shall be by or directly under the supervision of a professional engineer registered in New York State.

4.3.2 The formwork shall be designed for the loads and lateral pressures outlined in "Recommended Practice for Concrete Formwork" (ACI 347) and wind loads as specified by the New York City Building Code. Design considerations and allowable stresses shall meet ACI 347 and the applicable requirement of the New York City Building Code.

4.3.3 Requirements for facing materials are described in Chapter 10 (Finishing of Structural Concrete Formed Surfaces). For smooth form finish, the arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to a practical minimum. Support facing material with studs or other backing capable of preventing excessive deflection within the tolerances specified. The maximum deflection of facing materials reflected in concrete surfaces exposed to view shall be 1/240 of the span between structural members. Suitable moldings or chamfers measuring 3/4 in. minimum across the flats shall be placed in the corners of the column, beam and wall forms where the concrete will be exposed to view. Interior corners on permanently exposed surfaces and the edges or formed joints shall have chamfer strips.

4.3.4 The formwork shall be cambered to compensate for anticipated deflections in the formwork due to the weight and pressure of the fresh concrete and due to construction loads. To maintain specified tolerances, camber formwork to compensate for anticipated deflections in formwork prior to hardening of the concrete. Set forms and intermediate screed strips for slabs accurately to produce the designated elevations and contours of the finished surface. Ensure that edge forms and screed strips are sufficiently strong to support vibrating screeds or roller pipe screeds if the nature of the finish specified requires the use of such equipment. When formwork is cambered, set screeds to a like camber to maintain the proper concrete thickness.

4.3.5 Positive means of adjustment (wedges or jacks) or shores and struts shall be provided and all settlement shall be taken up during concrete placing operation. These devices shall be securely braced against lateral deflections.

4.3.6 Temporary openings shall be provided at the base of column forms and wall forms and at other points to facilitate cleaning and observation immediately before the concrete is deposited.

4.3.7 Form accessories to be partially or wholly embedded in the concrete, such as ties or hangers, shall be a commercially manufactured type. Nonfabricated wire is not acceptable. Construct form ties so the ends or end fasteners can be removed without causing appreciable spalling at the faces of the concrete. The portion remaining within the concrete shall leave no metal within 3/4 in. of the surface.

4.3.7.1 Form ties for all structures containing liquid shall have Water Stops at mid-thickness of the wall.

4.3.8 Forms shall be cleaned and inspected immediately prior to depositing concrete. Deformed, broken or defective forms shall be removed from the work.

4.3.9 Joints shall be snug and tight and shall occur only at the designated locations. Horizontal joints shall be level and vertical joints plumb. Design formed joints to the following requirements.

4.3.9.1 Locate and form construction joints to least impair the strength of the structure and to be acceptable. In general, locate construction joints near the middle of the spans of slabs, beams, and girders, unless a beam intersects a girder at this point. In this case, the joint in the girder shall be offset a distance equal to twice the width of the beam. Locate joints in walls and columns at the underside of floors, slabs, beams, or girders and at the top of footings or floor slabs. Make joints perpendicular to the main reinforcement.

4.3.9.2 Provide keyways as indicated on the Contract Documents. Provide longitudinal key ways at least 1 ½ in. deep in all joints in walls and between walls and slabs or footings.

4.3.9.3 Locate and detail control joints as indicated on the Contract Documents. Control joints other than those shown on the Contract Drawings shall be approved by the Engineer.

4.3.10 Fasten wedges firmly in place after final adjustment of forms prior to concrete placement.

4.3.11 Anchor formwork to shores or other supporting surfaces or members to prevent upward or lateral movement of any part of the formwork system during concrete placement.

4.3.12 Construct wood forms for wall openings to facilitate loosening and to counteract swelling of the forms.

4.3.13 Provide runways for moving equipment with struts or legs and support the runways directly on the formwork or structural member without resting on the reinforcing steel.

4.3.14 Place all sleeves, inserts, anchors, and embedded items required for adjoining work or for support of adjoining work prior to concreting.

4.3.15 Position accurately and support against displacement expansion joint material, Water Stops, and other embedded items. Fill voids in sleeves, inserts, and anchor slots temporarily with readily removable material to prevent the entry of concrete into the voids.

4.4 Tolerances

4.4.1 Unless otherwise specified by the architect/engineer, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits listed in Table 4.4.1.

4.4.2 The contractor shall establish and maintain in an undisturbed condition and until final completion and acceptance of the project sufficient control points and bench marks to be used for reference purposes to check tolerances.

4.4.3 Regardless of the tolerance limits listed in Table 4.4.1, no portion of the building shall extend beyond the legal boundary of the building.

4.4.4 Permissible variations from plumb and designated building lines for portions of buildings more than 100 ft above the ground shall be as specified in the contract documents.

4.4.5 Structural framing of reinforced concrete around elevators and stairways shall be accurately plumbed and located with 1/4 in. tolerance from established dimensions.

TABLE 4.4.1 - TOLERANCES FOR FORMED SURFACES

(1) Variation from plumb:

(A) In the lines and surfaces of columns, piers, walls, and in arises:
In any 10 ft of length ..... 1/4 in.
Maximum for the entire length ..... 1 in.

(B) For exposed corner columns, control-joint grooves, and other conspicuous lines:
In any 20 ft length ..... 1/4 in.
Maximum for the entire length ..... ½ in.

(2) Variations from the level or from the grades specified in the contract documents:

(A) In slab soffits, ceilings, beam soffits and in arises, measured before removal of supporting shores:
In any 10 ft of length ..... 1/4 in.
In any bay or in 20 ft length ..... 3/8 in.

(B) In exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines:
In any bay or in 20 ft length ..... 1/4 in.
Maximum for the entire length ..... ½ in.

(3) Variation of the linear building lines from established position in plan and related position of columns, wall, and partitions:
In any bay ..... ½ in.
In any 20 ft of length ..... ½ in.
Maximum for the entire length ..... 1 in.

(4) Variation in the sizes and location of sleeves, floor openings, and wall openings ... . ±1/4 in.

(5) Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls:
Minus .... 1/4 in.
Plus .... ½ in.

(6) Footings*

(A) Variations in dimensions in plan:
Minus ..... ½ in.
Plus ..... 2 in.

(B) Misplacement or eccentricity:
2 percent of the footing width in the direction
of misplacement but not more than ..... 2 in.

(C) Thickness:
Decrease in specified thickness ..... 5 percent
Increase in specific thickness ..... No limit

(7) Variation in steps:

(A) In a flight of stairs:
Rise ..... ±1/8 in.
Tread ..... ±1/4 in.

(B) In consecutive steps:
Rise ..... ±1/16 in.
Tread ..... ±1/8 in.

*Tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel, dowels, or embedded items.

4.5 Preparation of Formed Surfaces

4.5.1 Forms shall be sufficiently tight to prevent leakage of grout or cement paste.

4.5.2 Plywood and other wood surfaces shall be coated against absorption of moisture from the concrete by either:

4.5.2.1 A field applied, approved form oil or sealer, or

4.5.2.2 A factory applied nonabsorptive liner.

4.5.3 When forms are coated to prevent bond with concrete, it shall be done prior to placing of the reinforcing steel. Excess coating material shall not be allowed to stand in puddles in the forms nor allowed to come in contact with concrete against which fresh concrete will be placed.

4.5.4 Where as-cast finishes are required, materials which will impart a stain to the concrete shall not be applied to the form surface. Where the finished surface is required to be painted, the material applied to form surfaces shall be compatible with the type of paint to be used.

4.5.5 All form surfaces shall be cleaned before reuse. Panels shall not be reused for finished concrete work until they have been inspected and approved.

4.6 Construction and Erection of Forms

4.6.1 At construction joints, lap the contact surface of the form sheathing for flush surfaces exposed to view over the hardened concrete in the previous placement by not more than 1 inch. Ensure that forms are held against hardened concrete to prevent offset or loss of mortar at construction joints and to maintain a true surface.

4.7 Removal of Forms

4.7.1 When repair of surface defects or finishing is required at any early age, remove forms as soon as the removal operations will not damage the concrete.

4.7.2 Remove top forms on sloping surfaces of concrete as soon as removal operations will not allow the concrete to sag. Perform any needed repairs or treatment required on sloping surfaces at once and follow immediately with the specified curing.

4.7.3 Loosen wood forms for wall opening without causing damage to the concrete.

4.7.4 Formwork for columns, walls, sides of beams, and other parts not supporting the weight of the concrete may be removed as soon as the concrete has hardened sufficiently to resist damage from removal operations, particularly when form ties will be bent by the removal operations. Construct forms to permit easy removal. Do not pry against the face of the concrete. Only wooden wedges shall be used. Perform any requested repair and any treatment required by Supervising Engineer for Concrete Construction on the vertical surfaces at once and follow immediately with the specified curing.

4.7.5 Formwork for beam soffits and slabs and other parts that support the weight of concrete, shall remain in place until the concrete has attained the specified compressive strength, f'c. Forms and shoring may be removed at a lower compressive strength when specified or permitted in the Contract Documents. The Contractor shall demonstrate to the Supervising Engineer for Concrete Construction or his authorized representative that the safety of the structure is assured without overstress. When shores and other vertical supports are arranged so the nonload-carrying form facing material may be removed without loosening or disturbing the shores and supports, the facing material may be removed at an earlier age as specified or permitted by ACI 318 and ACI 347.

4.7.6 Whenever the formwork is removed during the curing period, the exposed concrete shall be cured by one of the methods specified in Chapter 12 (Curing and Protection).

4.8 Reshoring

4.8.1 When reshoring is permitted or required the operations shall be planned in advance and in accordance with acceptable procedures. Reshoring procedures shall be prepared in accordance with Section 4.2.6 by a New York State registered professional engineer.

4.8.2 During reshoring do not allow concrete in beam, slab, column, or any other structural member to be loaded with combined dead and construction loads in excess of the loads permitted by the Engineer for the developed concrete compressive strength at the time of reshoring.

4.8.3 Place reshores after stripping operations are complete but in no case later than the end of the working day on which stripping occurs.

4.8.4 Reshoring for the purpose of early form removal shall be performed so that at no time will large areas of new construction be required to support their own weight. While reshoring is under way, no live loads shall be permitted on the new construction. Reshores shall be tightened to carry their required loads but they shall not be overtightened so that the new construction is overstressed. Reshores shall remain in place until the concrete has reached its specified 28-day strength, unless otherwise specified.

4.8.5 For floors supporting shores under newly placed concrete, leave in place the original supporting shores or reshore. The shoring or reshoring system shall have a capacity sufficient to resist the anticipated loads and in all cases shall have a capacity equal to at least one-half of the capacity of the shoring system above. Reshores shall be located directly under a reshore position above unless other locations are permitted.

4.8.6 In multi-story buildings extend reshoring over a sufficient number of stories to distribute the weight of newly placed concrete, forms, and construction live loads so the design superimposed loads of the floors supporting shores are not exceeded.

4.9 Removal Strength

When formwork removal or reshoring removal is based on the concrete reaching its specified 28-day strength (or a specified percentage thereof) the concrete shall be presumed to have reached this strength when either of the following conditions has been met:

4.9.1 When test cylinders, field cured along with the concrete they represent, have reached the compressive strength specified for removal of formwork or reshoring. Mold the cylinders in accordance with ASTM C31, and test the cylinders in accordance with ASTM C39.

4.9.2 When the concrete has been cured in accordance with the specified provisions for the same length of time as the age at test of laboratory-cured cylinders which have reached the specified strength. Determine the length of time the concrete has been cured in the structure by the cumulative number of days or fractions thereof, during which the temperature of the air in contact with the concrete is above 50°F (10°C) and the concrete has been damp or thoroughly sealed from evaporation and loss of moisture.

Alternatively, if specified, the strength of the concrete may be determined by the methods in 4.9.3.

4.9.3 The following alternate methods for evaluating concrete strength for form removal may be permitted.

4.9.3.1 Tests of cast-in-place cylinders in accordance with ASTM C873. This is limited to slabs with concrete depth from 5 to 12 inches.

4.9.3.2 Penetration resistance in accordance with ASTM C803.

4.9.3.3 Pullout strength in accordance with ASTM C900.

4.9.3.4 Acceptable maturity factor procedure.

4.9.4 Prior to using methods in 4.9.3.1 through 4.9.3.4, submit sufficient data using job materials to demonstrate correlation of measurements on the structure with the compressive strength of laboratory cured molded cylinders or drilled cores. Correlation data for each alternate method for determining strength shall be submitted to the Engineer for acceptance.

END OF CHAPTER

CHAPTER 5 - REINFORCEMENT

5.1 General

5.1.1 Placing drawings showing all dimensions necessary for fabrication and placing of the reinforcing steel and accessories without reference to the project drawings shall be submitted for approval. Approval shall be obtained before fabrication.

5.1.2 Details of concrete reinforcement not covered herein shall be in accordance with "Building Code Requirements for Reinforced Concrete" (ACI 318), "Manual of Standard Practice for Detailing Reinforced Concrete Structures" (ACI 315), and the Concrete Reinforcing Steel Institute Manual on "Placing Reinforcing Bars".

5.1.3 No concrete shall be deposited until the Supervising Engineer for Concrete Construction or his approved representative has inspected the placing of the reinforcing steel and has given permission to place the concrete. Concrete placed in violation of this provision may be rejected with subsequent removal by the Contractor.

5.1.4 Mill Reports - Certified Copies of Mill Reports shall accompany all deliveries of reinforcing steel on work utilizing 15 tons or more.

5.2 Submittals

5.2.1 Placing drawings showing fabrication dimensions and locations for placement of reinforcement and supports.

5.2.2 Description of reinforcement weld locations and weld procedures.

5.2.3 Requests to relocate any bars that cause placing tolerances to be violated.

5.2.4 Proposed supports for coated reinforcement and uncoated reinforcement not covered in 5.5.

5.2.5 Request to use splices not shown on the Contract Drawings.

5.2.6 Request to use mechanical connections.

5.2.7 Request for placement of column dowels without the use of templates.

5.2.8 Request and procedure to field bend or straighten partially embedded reinforcement.

5.2.9 When it is found necessary to move reinforcement beyond the specified placing tolerances to avoid interference with other reinforcement, conduits, or embedded items, a submittal showing the resulting arrangement of reinforcement.

5.3 Reinforcement

5.3.1 All reinforcement shall be deformed except spirals and welded wire fabric, which may be plain bars. Reinforcement shall be the grades required by the contract documents and shall conform to one of the following specifications.

5.3.1.1 ASTM A615.

5.3.1.2 ASTM A616 including supplementary requirements S1.

5.3.1.3 ASTM A617.

5.3.1.4 ASTM A706.

5.3.1.5 Wire or wire fabric with a specified yield strength fy exceeding 60,000 psi shall have the stress fy corresponding to a strain of 0.35 percent.

5.3.2 Coated reinforcing bars - when specified, coated reinforcing bars shall be zinc-coated (galvanized or epoxy coated). The reinforcing bars to be coated shall conform to Section 5.3.1.

5.3.2.1 Zinc-coated (galvanized) reinforcing bars shall conform to ASTM A767. Supplementary requirements S1 and S2 shall apply when fabrication after galvanization includes cutting and bending. Supplementary requirement S2 shall apply when fabrication after galvanization includes only bending. Repair of damaged zinc coating when required shall be made with a zinc-rich formulation conforming to ASTM A767. Repair shall be done in accordance with the material manufacturer's recommendations.

5.3.2.2 Epoxy-coated reinforcing bars shall conform to ASTM A775. Coating damage due to shipping, handling, and placing need not be repaired in cases where the damaged area is 0.1 square in. or smaller. Repair damaged areas larger than 0.1 square in. with patching material conforming to ASTM A775 and in accordance with the material manufacturer's recommendations. The maximum amount of damage including repaired and unrepaired areas shall not exceed 2 percent of the surface area of each bar. Fading of the coating color will not be cause for rejection of epoxy-coated reinforcement.

5.3.3 Bar Mats

5.3.3.1 Bar mats shall be of the clipped type conforming to ASTM A184 and shall be fabricated from reinforcing bars that conform to Sections 5.3.1.1 through 5.3.1.4.

5.3.3.2 Bar mats may be fabricated from zinc-coated (galvanized) reinforcing bars. Metal clips shall be zinc-coated (galvanized). Nonmetallic clips may be used. Coating damage at the clipped intersections shall be repaired in accordance with Section 5.3.2.1.

5.3.3.3 Bar mats may be fabricated from epoxy-coated reinforcing bars. Metal clips shall be epoxy-coated. Nonmetallic clips may be used. Coating damage at the clipped intersections shall be repaired in accordance with Section 5.3.2.2.

5.3.4 Wire

5.3.4.1 Wire shall be smooth or deformed wire as indicated on the contract documents.

5.3.4.2 Smooth wire shall conform to ASTM A82.

5.3.4.3 Deformed wire shall conform to ASTM A495, size D4 and larger.

5.3.5 Welded wire fabric

5.3.5.1 Welded wire fabric shall be fabricated from smooth or deformed wire and shall conform to the wire size and wire spacing required or indicated on the contract documents. Welded wire fabric shall conform to one of the following specifications:

5.3.5.2 Plain wire fabric ASTM A185, except welded intersections shall be spaced not farther apart than 12 in. in the direction of the principal reinforcement.

5.3.5.3 Deformed wire fabric ASTM A497, except welded intersections shall be spaced not farther apart than 16 in. in the direction of the principal reinforcement.

5.3.6 Spirals - Spirals may be fabricated from reinforcing bars or wire.

5.4 Wire Bar Supports

5.4.1 Unless otherwise specified or permitted, wire bar supports shall be in accordance with Class 1, maximum protection, or Class 2, moderate protection in Chapter 3 of Manual of Standard Practice by the Concrete Reinforcing Steel Institute.

5.5 Coated Wire Reinforcement Supports

5.5.1 For Epoxy-Coated Reinforcement - Use wire reinforcement supports coated with dielectric material including epoxy or other polymer for a minimum distance of 2 in. from the point of contact with epoxy-coated reinforcement.

5.5.2 For Zinc-Coated Reinforcement - Use galvanized wire reinforcements supports or wire reinforcement supports coated with dielectric material.

5.6 Precast Concrete Reinforcement Supports

5.6.1 Concrete supports used for supporting reinforcement shall be not less than 4 in. square having a compressive strength equal to or greater than the specified compressive strength of the concrete being placed.

5.7 Welding

5.7.1 When required or permitted, all welding of reinforcing bars shall conform to AWS D1.4. Unless otherwise accepted, welding of crossing bars (tack welding) for assembly of reinforcement is prohibited.

5.7.2 Welding of wire to wire, and of wire or welded wire fabric to reinforcing bars or structural steels, shall conform to applicable provisions of AWS D1.4 and any supplementary requirements specified by the Supervising Engineer for Concrete Construction for the particular application.

5.7.3 After completion of welding on zinc-coated (galvanized) or epoxy-coated reinforcing bars, coating damage shall be repaired in accordance with Section 5.3.2.1 or 5.3.2.2, respectively. All welds, and all steel splice members when used to splice bars, shall be coated with the same material used for repair of coating damage.

5.8 Fabrication

All reinforcement shall be bent cold unless otherwise permitted.

5.9 Fabricating and Placing Tolerances

5.9.1 Reinforcing bars shall be fabricated in accordance with the standard fabricating tolerances in Figures 4 and 5 of ACI 315. Tolerances shall not permit a reduction in cover.

5.9.2 Reinforcement shall be placed to the following tolerances:

	Tolerances, in.
Clear distance	
To formed soffit	-1/4
To other formed surfaces	±1/4
Minimum spacing between bars	-1/4
Clear distance from unformed surface to top reinforcement	
Members 8 in. deep or less	±1/4
Members more than 8 in. deep but less than 24 in. deep	-1/4,+½
Members 24 in. deep or greater	-1/4,+1
Uniform spacing of bars, but the required number of bars shall not be reduced	±2
Uniform spacing of stirrups and ties, but the number of stirrups and ties shall not be reduced	±1
Longitudinal locations of bends and ends of reinforcement	
General	±2
Discontinuous ends of members	±½
Length of bar laps	-1 ½
Embedded length	
For bar sizes No. 3 through 11	-1
For bar sizes No. 14 and 18	-2

5.9.3 When it is necessary to move bars to avoid interference with other reinforcement, conduits, or embedded items exceeding the specified placing tolerances, the resulting arrangement of bars shall be subject to acceptance of the Engineer.

5.10 Placing

5.10.1 Minimum concrete cover for reinforcement, except for extremely corrosive atmosphere, other severe exposures, or fire protection, shall be as follows unless indicated otherwise on the contract documents.

TABLE 5.10.1

	Minimum Cover, in.
Slabs and Joists:	
Top and bottom bars for dry conditions	
No. 11 bars and smaller	3/4 in.
No. 14 and No. 18 bars	1-1/2 in.
Bars in formed concrete surfaces exposed to water or weather, and over or in contact with sewage and for bottoms bearing on work mat, or slabs supporting earth cover.	
No. 5 bars and smaller	1-1/2 in.
No. 6 through No. 18 bars	2 in.
Beams and Columns:	
For dry conditions:	
Stirrups, spirals, and ties	1-1/2 in.
Principal reinforcement	2 in.
Exposed to earth, water, sewage, or weather:	
Stirrups and ties	2 in.
Principal reinforcement	2-1/2 in.
Walls:	
For dry conditions:	
No. 11 bars and smaller	3/4 in.
No. 14 and No. 18 bars	1-1/2 in.
Formed concrete surfaces exposed to earth, water, sewage, weather, or in contact with ground:	2 in.
Footings and base slabs:	
At formed sides and ends and bottoms bearing on concrete work mat	2 in.
At unformed surfaces and bottoms in contact with earth	3 in.
Top of footings	same as slabs
Over top of piles	2 in.

5.10.1.1 For bundled bars, minimum concrete cover shall be equal to the equivalent diameter of the bundle but need not be greater than 2 in.; except for concrete deposited against and permanently in contact with ground, minimum cover shall be 3 in. The equivalent diameter of the bundle shall be based on a single bar of a diameter derived from the equivalent total area.

5.10.2 All reinforcement, at the time concrete is placed, shall be free of mud, oil, or other materials that may adversely affect or reduce the bond. Reinforcement with rust, mill scale, or a combination of both

shall be considered satisfactory provided the minimum dimensions, weight, and height of deformations of a hand-wire-brushed test specimen are not less than the applicable ASTM specification requirement.

5.10.3 All reinforcement shall be supported and fastened before concrete is placed and shall be secured against displacement within the tolerances permitted in Section 5.9.2.

5.10.3.1 Unless otherwise indicated in the contract documents, reinforcement supported from the ground or mud mat shall rest on precast concrete blocks not less than 4 in. square and having a compressive strength equal to or greater than the specific compressive strength of the concrete being placed. Other means of support may be used if accepted.

5.10.3.2 Reinforcement supported from formwork shall rest on bar supports made of concrete, metal, plastic, or other acceptable materials. Where the concrete surface will be exposed to the weather in the finished structure, the portions of all bar supports within ½ in. of the concrete surface shall be noncorrosive or protected against corrosion.

5.10.3.3 Zinc-coated (galvanized) reinforcing bars supported from formwork shall rest on galvanized wire bar supports coated with dielectric material, or on bar supports made of dielectric material or other acceptable materials. All other reinforcement and embedded steel items in contact with galvanized reinforcing bars, or within a minimum clear distance of 2 in. from galvanized reinforcing bars unless otherwise required or permitted, shall be galvanized.

5.10.3.4 Epoxy-coated reinforcing bars supported from formwork shall rest on coated wire bar supports, or on bar supports made of dielectric material or other acceptable materials. Wire bar supports shall be coated with dielectric material for a minimum distance of 2 in. from the point of contact with the epoxy-coated reinforcing bars. Reinforcing bars used as support bars shall be epoxy coated. In walls having epoxy-coated reinforcing bars, spreader bars, where specified, shall be epoxy coated. Proprietary combination bar clips and spreaders used in wall with epoxy-coated reinforcing bars shall be made of corrosion-resistant material or coated with dielectric material.

5.10.3.5 Zinc-coated (galvanized) reinforcing bars shall be fastened with zinc-coated tie wire, or nonmetallic-coated tie wire, or other acceptable materials.

5.10.3.6 Epoxy-coated reinforcing bars shall be fastened with nylon-epoxy-, or plastic-coated tie wire; or other acceptable materials.

5.10.4 Welded wire fabric for slabs on grade shall extend to within 2 in. of the concrete edge. Welded wire fabric may extend through the contraction joints. Welded wire fabric shall be adequately supported during placing of concrete to assure proper positioning in the slab.

5.10.5 Templates shall be furnished for placement of all column dowels unless otherwise permitted.

5.10.6 All splices shall be as indicated on the contract documents unless otherwise permitted. Mechanical connections that provide a minimum of 125 percent of the yield strength of the reinforcing bars may be used when accepted. Reinforcement coating shall be removed in the area of the mechanical connection, if so required by the connection manufacturer. After installation of mechanical connections on zinc-coated (galvanized) or epoxy-coated reinforcing bars, coating damage shall be repaired in accordance with Section 5.3.2.1 or 5.3.2.2, respectively. All external parts of mechanical connections used on coated bars, including steel splice sleeves, bolts, and nuts shall be coated with the same material used for repair of coating damage.

5.10.7 Bending or straightening of bars partially embedded in concrete shall not be permitted except when specifically accepted. Bending shall be in accordance with Sections 5.10.7.1 and 5.10.7.2.

5.10.7.1 The minimum inside bend diameters shall conform to the requirements of Table 5.10.7, unless otherwise permitted. In addition, the beginning of the bend shall not be closer to the concrete surface than the minimum diameter of bend. Preheating, if required, shall be in accordance with Section 5.10.7.2. The following requirements shall be adhered to for individual bar sizes:

Bar size	Bend requirements
No. 3 through No. 5	Bars may be cold bent the first time. Cold bend bars only when temperature is above 32°F. Preheating is required for subsequent straightening or bending.
No. 6 and larger	Preheating is required.

TABLE 5.10.7 - Minimum diameter of bend

Bar Size	Minimum Diameter
No. 3 through 8	6 bar diameters
No. 9, 10, 11	8 bar diameters
No. 14 and 18	10 bar diameters

5.10.7.2 Preheating prior to bending or straightening, when required, shall be in accordance with the following requirements:

(a) Preheating may be applied by any method which does not harm the bar material or cause damage to the concrete.

(b) The preheat shall be applied to a length of bar equal to at least 5 bar diameters each way from the center of the bend except that preheat shall not extend below the surface of the concrete. The temperature of the bar at the concrete interface shall not exceed 500°F.

(c) The preheat temperature shall be 1100 to 1200°F.

(d) The preheat temperature shall be maintained until bending or straightening is complete.

(e) The preheat temperature shall be measured by temperature measurement crayons, contact pyrometer, or other acceptable method.

(f) Heated bars shall not be artificially cooled until the material temperature is less than 600°F.

5.10.7.3 Repair of damaged coating - When zinc-coated (galvanized) or epoxy-coated reinforcing bars are field bent, coating damage shall be repaired in accordance with Section 5.3.2.1 or 5.3.2.2, respectively.

5.10.8 Zinc-coated (galvanized) reinforcing bars - Coating damage due to handling, shipping, and placing shall be repaired in accordance with Section 5.3.2.1.

5.10.9 Epoxy-coated reinforcing bars - Equipment for handling epoxy-coated reinforcing bars shall have protected contact areas. Bundles of coated bars shall be lifted at multiple pickup points to prevent bar-to-bar abrasion from sags in the bundles. Coated bars or bundles of coated bars shall not be dropped or dragged. Coated bars shall be stored on protective cribbing. Coating damage due to handling, shipping, and placing shall be repaired in accordance with Section 5.3.2.2.

5.11 Fully Encased Structural Steel Members

5.11.1 Structural steel members fully encased in concrete shall be wrapped with 3 by 3 in. mesh of 10 gauge galvanized wire, applied around the steel over spacers to provide 3/4 in. clearance from the metal unless otherwise indicated on the contract documents. The edges of the mesh shall be lapped and tied and shall have all loose ends made fast. On members no greater than 30 in. in depth which have not been designed for composite action, beam clips or caging of a type approved by the Commissioner may be used in lieu of the mesh. Such beam clips or caging shall be of 10 gauge galvanized wire with clips or transverse wires 6 in. on centers or less, and have one (1) longitudinal wire for clips up to 8 in. wide; two (2) longitudinal wires for clips from 9 in. to 15 in. wide; three (3) longitudinal wires for clips from 16 in. to 20 in. wide, and four (4) longitudinal wires for clips from 21 in. to 25 in. wide. For columns, clips shall be applied to both flanges.

5.11.2 Fireproofing - Steel beams, girders, columns and such parts thereof as stiffeners, billets, brackets, seats and the like, but excepting supports for elevator guide rails shall be encased in concrete, cast monolithic with the arch construction except where otherwise shown on the drawings. Concrete for fireproofing of steel structural members and parts of same shall be placed so as to completely fill the space between the respective steel member and the form and provide at least 2 in. of protection at all points. The soffits of steel beams and girders and the bottoms of similar steel members and connections requiring fireproofing shall be provided with continuous fireproofing reinforcement. See Sections 2.6.5 and 3.7.1.

5.12 Exposed Reinforcement

5.12.1 Reinforcement left exposed for the bonding of future construction shall be effectively protected from corrosion by encasement in cement mortar or by other temporary covering as approved.

5.13 Field Cutting of Reinforcement

5.13.1 Reinforcement shall not be cut in the field except when specifically permitted by the Engineer in writing.

5.14 Reinforcement Through Expansion Joint

5.14.1 Reinforcement or other embedded metal items bonded to the concrete shall not be continuous through any joint intended as an expansion joint. Dowels bonded on only one side of a joint and Water Stops may extend through the joint.

END OF CHAPTER

CHAPTER 6 - JOINTS, EMBEDDED ITEMS, MISCELLANEOUS PRECAST AND CAST-IN PLACE ITEMS, CONCRETE ORNAMENTS, AND LIGHTWEIGHT CONCRETE FILLS

6.1 General

This chapter provides requirements for joints, embedded items, miscellaneous precast and cast-in-place items, concrete ornaments, and lightweight concrete fills.

6.2 Submittals

6.2.1 Identification of products/materials for expansion joint fillers.

6.2.2 Identification of products/materials and shapes of Water Stops.

6.2.3 Method to be used to roughen construction joints and achieve bond including product identification as applicable.

6.2.4 Samples of precast and cast-in-place concrete in accordance with Section 6.7.2.

6.2.5 Shop drawings and setting drawings of precast and cast-in-place concrete in accordance with Section 6.7.3.

6.2.6 A model of concrete ornaments in accordance with Section 6.8.

6.2.7 Equipment pad layout drawings.

6.3 Construction Joints

6.3.1 Joints shall comply with the provisions of Section 4.3.9.

6.3.2 All reinforcing steel and welded wire fabric shall be continued across joints. Inclined dowels shall be provided as detailed or directed by the Supervising Engineering for Concrete Construction.

6.3.3 The surface of the concrete at all joints shall be thoroughly cleaned and all laitance removed. Acceptable methods include:

6.3.3.1 The use of an approved chemical retarder applied in accordance with the manufacturer's recommendations which delays but does not prevent the setting of the surface mortar. Retarded mortar shall be removed within 24 hours after placing to produce a clean exposed aggregate bonding surface.

6.3.3.2 By roughening the surface of the concrete in an approved manner which will expose the aggregate uniformly and will not leave laitance, loosened particles of aggregate or damaged concrete at the surface.

6.3.4 Bond is required and shall be obtained by one of the following methods:

6.3.4.1 The use of an approved adhesive applied in accordance with the manufacturer's recommendations.

6.3.4.2 Use of Portland cement grout of similar proportions to the mortar in the concrete in an acceptable manner.

6.4 Expansion Joints

6.4.1 Reinforcement or other embedded items bonded to the concrete (except dowels in floors bonded on only one side of joint) shall not be permitted to extend continuously through any expansion joint.

6.4.2 This section describes Preformed Expansion Joint Filler. Preformed expansion joint filler shall be nonextruding, and shall be of the following types:

Type II Cork, conforming to ASTM Designation D1752, Type II.

Type III Self-expanding cork, conforming to ASTM Designation D1752, Type III.

Type IV Bituminous fiber, conforming to ASTM Designation D1751.

6.4.3 Unless otherwise specified:

Type II, or III shall be used in concrete pavements and structures.
Type IV shall be used in sidewalk and curbing.

Asphaltic blown joint filler for sealing joints over Type IV preformed joint filler shall comply with the requirement of Section 2.16 of the Standard Specifications of the NYC Department of Transportation, Bureau of Highway Operations.

6.4.4 This section describes Elastic Type Concrete Expansion Joint Sealer for sealing expansion and contraction joints in concrete pavements and structures.

6.4.4.1 Expansion sealer shall be of the following types:

Type 1 - Hot poured sealer shall comply with the requirement of ASTM D1190.

Type 2 - Cold Application sealer shall comply with the requirements of ASTM D1850.

6.4.4.2 Expansion joint sealer shall be a resilient and adhesive material which, when applied to the joints of concrete pavements and structures, will form an effective and continuous seal against infiltration of water through the joints during expansion and contraction.

6.4.4.3 Type 1 Expansion Joint Sealer shall be suitable for melting in an oil jacketed kettle. When uniformly heated to a safe temperature, it shall melt to such a consistency that it can be readily poured into a horizontal joint one-half (½) in. in width. Upon cooling to atmospheric temperature, it shall adhere to the sides of the joint and shall not crack or break or separate from the sides of the joint when exposed to freezing temperatures while being extended.

Type 2 Expansion Joint Sealer shall be capable of pouring or extruding at 70°F into joints one-quarter (1/4) in. in width. It shall be resilient and adhesive to concrete. It shall not flow from the joint or be picked up by vehicle tires at summer temperatures.

6.4.4.4 Expansion joint sealer shall have a least one (1) year of field service satisfactory to the Supervising Engineer for Concrete Construction.

6.5 Water Stops

6.5.1 The material, design and location of Water Stops in construction joints and expansion joints shall be as indicated in the project specifications and drawings. Water stop materials shall meet requirements of CRD C572 for polyvinylchloride water stop. Splices in water stops shall be made, and molded pieces used, as recommended by the manufacturer.

6.5.2 Each piece of premolded Water Stop shall be of maximum practicable length in order that the number of end joints will be held to a minimum.

6.5.3 Joints at intersections and at ends of pieces shall be made in the manner most appropriate to the materials being used. Joints shall develop effective watertightness fully equal to that of the continuous Water Stop material and shall permanently develop not less than 80 percent of the mechanical strength of the parent section and shall permanently retain its flexibility.

6.6 Work in Connection with Other Sections and/or Contracts

6.6.1 All sleeves, inserts, anchors and embedded items required for adjoining work or for its support shall be placed prior to concreting. No concrete shall be deposited until the Resident Engineer or his authorized representative has inspected the placement of the embedded items and the reinforcing bars and has given his permission to place the concrete.

6.6.2 All contractors, whose work is related to the concrete or must be supported by it, shall be given ample notice and opportunity to introduce and/or furnish embedded items before the concrete is placed.

6.6.3 Electrical conduits, junction boxes or pipes shall be placed prior to concreting by the Electrical, Plumbing and Heating and Ventilating Contractors. The General Construction Contractor under this Section shall cooperate in placing of such items of work in order that they are installed in accordance with all of the requirements of the New York City Building Code. The General Contractor shall protect such installations to the extent that they are not displaced or damaged during the placing of concrete.

6.6.4 Forms shall be provided with all necessary openings, pockets, slots, chases and the like required for the work of others, which are indicated on the contract drawings or for which direction are given, prior to placing concrete.

6.6.5 Opening in slabs shall be provided for pipes, conduits and the like required for the work of others where indicated on the contract drawings or for which directions are given prior to the placing of concrete. When the work of others is completed, the excess part of the respective openings shall be completely closed up to the pipe sleeve and/or inserts by the General Contractor to match the adjoining work.

6.6.5.1 Sleeves and inserts for mechanical work may be furnished and installed by other Contracts and the General Contractor. The General Construction Contractor shall allow ample time for the installation of these inserts and sleeves. Care shall be taken during concreting operations so as not to disturb these.

6.6.5.2 Sleeves for miscellaneous metal work, casting, pipes and anchors furnished under the General Construction Contract shall be set true and to proper alignment in the concrete as indicated on the Contract Drawings or required by manufacturer's templates.

6.7 Miscellaneous Precast and Cast-in-Place Items

6.7.1 Items of concrete that are not shown as cast integral with and forming a part of the reinforced concrete work, such as door and window sills, coping, chimney caps, other trim and separate items, and such other items noted in the detailed specifications shall be precast or cast-in-place to the design shown on the drawings. Miscellaneous precast and cast-in-place items do not include thin section precast concrete construction or precast concrete floor and roof units or precast wall or column sections.

6.7.2 Samples of precast and cast-in-place concrete showing the color, texture, finish and other physical properties shall be submitted for approval.

6.7.3 Shop and setting drawings of all precast and cast-in-place items of concrete work shall be submitted.

6.7.3.1 Working drawings shall be prepared from information shown on the contract drawings and at the site, where necessary, and shall show sizes, sections, reinforcement and dimension of units, the jointing, the sizes and locations of sinkages for dowels, anchors, etc, and all other necessary details. Each piece shall be numbered for ready identification in setting.

6.7.4 Mix Proportioning

6.7.4.1 Precast and cast-in-place items shall match the color and texture of the concrete at the adjacent areas except as otherwise modified in the detailed specifications. Concrete shall be air-entrained and shall be proportioned to yield a 28-day compressive strength of 4500 psi in accordance with the cement factors given in Table 3.9.2.3(I) except that slump shall be limited to between 1 ½ and 3 in.

6.7.4.2 Coarse aggregate for precast concrete shall consist of hard, durable, washed and screened gravel, or crushed stone and shall meet the requirements of and be graded in accordance with Sizes 7 or 8 (ASTM C33).

6.7.4.3 Sand for Precast Concrete shall consist of quartz or other approved hard and durable particles, free from clay, loam and organic matter and in all other respects conform to ASTM C33.

6.7.5 Water Absorption

Items shall have an absorption of not more than 6 percent by weight, after immersion in water for 48 hours.

6.7.6 Reinforcement - All slender precast and cast-in-place items shall be reinforced longitudinally with deformed bars. Where reinforcement is not shown on the contract drawings, it shall be equal to not less than one-half of one percent of the gross cross-sectional area of the respective items and shall be placed not closer than 1 1/4 in. from any outer face.

6.7.7 Anchorage - Provisions shall be made in precast concrete items for anchoring, doweling or otherwise securing same to the masonry.

6.7.8 Curing - Precast items shall be cured in accordance with Chapter 12, and upon delivery shall be subject to wetting and inspection for crazing, any major evidence of which may cause rejection; cast-in-place ornaments and miscellaneous items shall be cured in accordance with Chapter 12.

6.7.9 Workmanship - Precast and cast-in-place items shall simulate the cast-in-place concrete, be accurately shaped and free from blemishes and defects which would impair strength, durability and appearance.

6.7.9.1 Sills and copings shall have a hard smooth finish, and when shown with an exterior overhang shall have a drip-groove on the underside.

6.7.9.2 Items cast in sections shall have allowance for joints between sections of 1/4 in. and the ends shall be roughened for bond.

6.7.9.3 Finishing - All surfaces of items which will be exposed in the finished work shall be finished in accordance with Chapter 10, Section 10.3, Chapter 11, Section 11.9, or Chapter 13, Section 13.10.1 unless otherwise specified.

6.7.10 Setting - Precast units shall be accurately set in accordance with approved setting drawings, true to line and level, and have all joints completely filled with mortar, including sinkages about dowels and anchors. The face joints on the washes of copings and sills shall be raked out to a depth of one-half (½) in. for filling solid with caulking compound.

6.7.10.1 Mortar for setting precast concrete items shall be the same as used for adjoining masonry work.

6.7.10.2 Do all cutting and fitting in the field necessary to overcome any inaccuracies in the work or to make the items fit and conform to the structural conditions at the building.

6.7.10.3 Adjoining surfaces shall be flush and irregularities that may occur shall be dressed to the proper surface and be refinished.

6.8 Concrete Ornaments

6.8.1 Cast-in-place concrete ornaments shall comply with Section 6.6.4.1. When required, in order to produce an ornament of fine detail, the maximum size of coarse aggregate may be reduced. Molds for band courses or cap members may be built into the forms.

6.8.2 Precast ornaments shall be set into the structural concrete not less than 2 in., and shall be placed during the casting of the structural concrete.

6.8.3 For other than simple molded work, a model or wood, plaster or other suitable substance shall be submitted to the Commissioner for approval. Waste molds of plaster or wood shall be made from the approved model. Plaster molds shall be reinforced with jute fiber and required bracing. Wood molds shall be clear lumber kerfed in back for easy removal, shall be wedged between projections, and shall have joints arranged to present the least notice in the finished surface. Molds shall be constructed of simply shaped and easily handled sections. Surfaces of molds designed for concrete contact shall be shellacked with two coats at the shop and an additional coat after assembly of the mold.

6.9 Placing Embedded Items

6.9.1 Expansion joint material, Water Stops, and embedded items shall be positioned accurately and supported against displacement. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable materials to prevent the entry of concrete into the voids.

6.9.2 Pipe, conduits and castings in concrete shall be embedded at least 3 in., except in thin floor slabs.

6.10 Lightweight Concrete Fill

6.10.1 Lightweight concrete fill shall be composed of a mixture of Portland cement, sand, lightweight coarse aggregate and water to produce the specified weight and strength. Coarse aggregate shall be lightweight aggregate such as expanded blast furnace slag, pumice, expanded carbonaceous shale or other approved lightweight aggregate.

6.10.2 Lightweight concrete fill shall be proportioned to obtain a minimum ultimate compressive strength of 300 lb per square in. after 28 days and shall weigh between 75 and 90 lb per cubic foot. Mixing shall be done in accordance with the written directions of the manufacturer of the lightweight aggregate.

6.10.3 Lightweight concrete fill for roofs shall be placed immediately after mixing and shall be evenly spread and tamped and screed coated. The screed coat shall be floated to a smooth even surface without ridges or indentations and shall be made ready to receive the roofing or insulating material. The minimum thickness at roof drains shall be not less than two in. and the fill shall slope upwards not less than 1/8 in. per foot. Lightweight concrete fill for floors shall be evenly spread and tamped. Top of fill shall be parallel to the finished floor surfaces. Concrete surfaces shall be thoroughly cleaned and then brushed with a cement grout just prior to placing fill. Fill shall not be placed in freezing weather.

6.11 Other Fills

6.11.1 Other Fills shall be as specified in the Detailed Specifications.

END OF CHAPTER

CHAPTER 7 - PRODUCTION OF CONCRETE

7.1 General

This chapter provides requirements for the production of concrete which includes batching, mixing, delivering, and discharging of concrete.

7.2 Submittals

7.2.1 Identification of Ready-Mixed Concrete Supplier including the plant location and all pertinent information of Section 7.4.1 locations of sources of materials for cement, fine and coarse aggregates, and water, and the brands and types of admixtures to be used.

7.2.2 All information pertinent to a concrete plant to be erected at the site per Section 7.4.1.

7.3 Ready-Mixed Concrete

7.3.1 Ready-Mixed concrete shall be batched, mixed and transported in accordance with the appropriate sections of "Specifications for Ready-Mixed Concrete" (ASTM C94). Follow the detailed recommendations given in Guide for Measuring, Mixing, Transporting, and Placing Concrete (ACI 304), where applicable.

7.3.2 Each truck mixer or agitator shall have attached thereto in a prominent place a metal plate issued by the Truck Mixer's Manufacturer's Bureau by the manufacturer complying with Section 8.1.2 of ASTM C94 for that truck mixer and the limitations thereon shall be strictly adhered to.

7.3.3 Ready-mixed concrete shall only be batched in plants which meet the requirements of the latest standards for certification of the National Ready-Mix Concrete Association.

7.3.3.1 Upon written application by the producer, accompanied by a detailed report on how the facilities compare with the standards of the N.R.M.C.A., the above requirements may be waived, in writing by the Engineer.

7.3.3.2 If the detailed report mentioned above is issued by the testing agency which will perform the inspection of the batching and mixing of the concrete and indicates that satisfactory quality concrete can be produced by the plant in question, based on prior job performance records, then the above requirement will be waived, in writing, by the Supervising Engineer for Concrete Construction.

7.3.4 Approval of plants as outlined above is subject to the continuous checking and acceptance by the Commissioner or his duly authorized representative.

7.3.5 Only plants meeting the requirements for certification of the N.R.M.C.A. for automatic batching and automatic recording will be permitted.

7.3.5.1 If at any time automatic proportioning or recording instruments become inoperative, the plant may be allowed to batch concrete manually or operate with manual recording for a period of not more than 48 working hours from the time of breakdown.

7.3.5.2 If at the end of 48 working hours, the plant is still not in operating order, the following shall be complied with:

(a) An inspector other than the regular plant inspector shall be assigned to each batching operation at the plant.

(b) Additional inspectors shall observe and record the weight of each component of the batch.

(c) The manually recorded batch weights shall appear on a ticket presented to inspection personnel at the project site.

7.4 Batch Mixing at Site

7.4.1 The concrete shall be produced in a plant conforming to the requirements of the Concrete Plant Standards and Concrete Plant Mixer Standards of the Concrete Plant Manufacturer's Bureau. Prior to erection of such plant at the site, the contractor shall submit to the Supervising Engineer for Concrete Construction, for approval, all pertinent data relative to the plant.

7.4.2 All components of the plant must bear the proper rating plates issued by the Concrete Plant Manufacturers Bureau and the limitations thereon shall be strictly adhered to.

7.4.3 On job site plants for jobs requiring less than 1000 cubic yards of structural concrete or a job site plant that would operate for less than 30 working days duration, the requirements of 7.3.5 above for automatic batching and automatic recording will be waived. If at any time automatic proportioning devices or recording instruments become inoperative, follow the provisions of 7.3.5.1 and 7.3.5.2.

7.4.4 The batch shall be so charged into mixer that some water will enter in advance of the cement and aggregates. Water shall continue to flow for a period which may extend to the end of the first 25 percent of the specified mixing time. Controls shall be provided to insure that the batch cannot be discharged until the required mixing time has elapsed. When concrete of normal weight is specified, controls shall be provided to insure that no additional water may be added during mixing. The entire batch shall be discharged before the mixer is recharged.

7.4.5 Each batch of 2 cu yd or less shall be mixed for not less than 1 ½ minutes. The mixing time shall be increased 15 seconds for each additional cubic yard or fraction thereof. Shorter mixing time may be permitted provided performance tests made in accordance with ASTM C94 indicate that the time is sufficient to produce uniform concrete. At least three quarters of the required mixing time shall take place after the last of the mixing water has been added. The interior of the mixer shall be free of accumulations that will interfere with mixing action. Replace mixer blades when they have lost 10 percent of their original weight.

7.4.6 When small quantities of concrete are produced on the site, measure solid materials by weight, and liquid or paste materials by weight or by volume. Mix all materials in a mechanical mixer. If packaged dry combined materials are used, they shall conform to the requirements of ASTM C387, and shall be capable of satisfying the requirements of this Standard Specification.

7.5 Control of Admixtures

7.5.1 Air entraining and chemical admixtures shall be charged into the mixture as a solution and shall be dispensed by an automatic dispenser or similar measuring device. The accuracy of measurement of any admixture shall be within ±3 percent. Admixtures shall be charged into the mixer in such manner as not to come into direct contact with the cement.

7.5.2 Two or more admixtures may be used in the same concrete provided such admixtures are added separately during the batching sequence and provided further that evidence is submitted to show that the admixtures used in that combination retain full efficiency and have no deleterious effect on the concrete or on the properties of each other.

7.5.3 All admixtures shall be added prior to mixing.

7.6 Structural Lightweight Concrete

7.6.1 This section covers the requirements for production of structural lightweight concrete and appurtenances in structures. Portions of the structure to be treated as lightweight concrete under the provisions of this Section are so designated on the Contract Drawings. Lightweight concrete shall comply with all requirements of this specification unless otherwise specified in the Detailed Specification.

7.6.2 Product Delivery, Storage, and Handling

7.6.2.1 Cover or presoak coarse and fine lightweight aggregates when transporting them.

7.6.2.2 Presoak dry lightweight aggregates unless presoaking is not recommended by the aggregate supplier or is not acceptable to the Engineer. Leave presoaked aggregates in the stockpile after soaking for at least 12 hours before using.

7.6.2.3 Do not allow machinery to run over lightweight aggregates.

7.6.3 Materials

7.6.3.1 Fine and coarse lightweight aggregates for lightweight concrete shall conform to ASTM C330. From 20 to 35 percent shall pass the No. 50 (0.297 mm) sieve and 10 to 20 percent shall pass the No. 100 (0.149 mm) sieve in the sand fraction gradation. Normal weight aggregate for lightweight concrete shall conform to ASTM C33.

7.6.4 Performance and Design Requirements

7.6.4.1 Entrain air in lightweight concrete that will be exposed to freezing and thawing conditions. Use 6 ± 2 percent total air content when the nominal maximum size of aggregate is greater than 3/8 in. Use 7 ± 2 percent total air content when the normal maximum size is 3/8 or less. Determine the air content by the volumetric methods of ASTM C173. Select concrete mixture proportions for concrete to provide a compressive strength as required by the Contract Drawings.

7.6.4.2 Use ASTM C150 Type II or Type V cement for lightweight concrete required to be chemical-resistant. Select concrete mixture proportions to provide a specified minimum compressive strength 4000 psi, unless otherwise specified on the Contract Drawings.

7.6.4.3 Where required in the Contract Documents, proportion lightweight concrete mixtures for watertight portions of the structure to produce a specified compressive strength as specified on the Contract Drawings.

7.6.4.4 Floors - The slump of lightweight concrete for floors shall not exceed 4 in. (maximum) at the point of placement. For troweled floors, the slump of structural lightweight concrete with 100 percent normal weight sand discharged by pump shall not exceed 4 in. at the point of placement.

7.6.5 Mixtures

7.6.5.1 Proportion lightweight concrete mixtures to meet the specified limit on maximum air-dry unit weight as determined by the method of ASTM C567. Correlate the air-dry unit weight with the fresh unit weight of the same concrete to permit use of the latter as the basis for acceptance during construction.

7.6.5.2 Determine the cement factor needed to attain the required strength for lightweight concrete in accordance with the N.Y. City Administrative Building Code and relate strength to cement content of the concrete.

7.6.6 Batching and Mixing

7.6.6.1 Batch and mix lightweight aggregate concrete as recommended by the aggregate producer and the concrete producer, and in accordance with this Specification. If the procedure recommended by the aggregate producer and the concrete producer is at variance with this Specification, submit the producers' recommendations to the Engineer for acceptance.

7.6.6.2 For low absorption aggregate, batch and mix aggregate that has been shown to absorb less than 2 percent water by weight during the first hour after inundation. Test aggregate for water absorption with the minimum moisture content likely to occur on the job. Predampening may be used to achieve this condition.

7.6.6.3 For high absorption aggregate, batch and mix concrete made with lightweight aggregates absorbing 2 percent water by weight or more by:

(a) First add the aggregate to approximate 80 percent of the mixing water and mix for a minimum of 1 ½ minutes in a stationary mixer or 15 revolutions at mixing speed in a truck mixer.

(b) Then add any admixtures, the cement, and the withheld portion of mixing water and complete the mixing.

7.6.6.4 Slump Adjustment - Additional water may be added to the mixture, if needed, to bring the mixture to the specified slump after truck transport. Increase the slump of concrete entering the pump as required to maintain the specified slump at the point of placement.

7.6.6.5 The lightweight aggregate shall be presoaked by vacuuming, ponding, or sprinkling continuously with water until the aggregate moisture content is sufficient to minimize slump loss through the pump line. Slump loss through the pump line shall not exceed 4 in.. The presoaking period shall be up to 30 days or as required by the Engineer after determination at the batch plant.

7.6.7 Execution

7.6.7.1 Do not vibrate lightweight concrete to the point that large particles of aggregate float to the surface.

7.6.7.2 Do not work lightweight concrete to the point that mortar is driven down and an excess of the lightweight aggregate appears at the surface.

7.6.8 Field Quality Control

7.6.8.1 Base acceptance of lightweight concrete in the field on fresh unit weight measured in accordance with ASTM C567. The nominal fresh unit weight shall be that corresponding to the specified maximum air-dry unit weight calculated from the formula for approximate air-dry weight in ASTM C567. When the nominal fresh unit weight varies by more than 2 lb/ft from the required weight, adjust the mixture as promptly as conditions permit to bring the unit weight to the desired level. Do not use any batch for which fresh unit weight varies by more than 3 lb/ft from the desired level.

7.6.8.2 Determine the total air content of the lightweight concrete sample for each strength test in accordance with ASTM C173.

7.7 Tempering and Control of Mixing Water

7.7.1 Concrete shall be mixed only at the mix plants or at the job site. Concrete shall be mixed in quantities not to exceed immediate job placement requirements.

7.7.2 The addition of any water to the mix while the truck is en route from plant to job site is strictly prohibited. Mixing in transit is strictly prohibited. Agitating in transit is permitted, but shall be kept to a minimum.

7.7.3 When concrete arrives at the point of delivery with a slump below that which will result in the specified slump at the point of placement and is unsuitable for placing at that slump, the slump may be adjusted to the specified value by adding water if all the water required in the accepted mixture proportions has not been added at the start of mixing and if permitted by the Engineer. Addition of water shall be in accordance with ASTM C94. Neither the specified water-cement ratio nor slump shall be exceeded. Do not make slump adjustments after 15 percent of the batch has been unloaded. Do not add water to concrete containing a plasticizing or a high range water reducing admixture. Do not add water to concrete in delivery equipment not acceptable for mixing. Measure air content of air-entrained concrete, after slump adjustment, to verify compliance to specified requirements.

7.7.4 Each increment of water added at the job site must be incorporated by additional mixing by turning the drum not less than 30 revolutions. The addition of the increments of water and the start of the mixing procedures shall not be commenced earlier than one-half hour prior to the beginning of discharge. From the time the batch or load has been mixed to the specified slump, no further water shall be added to the concrete.

7.7.5 With the approval of the Supervising Engineer for Concrete Construction, when and if the maximum specified slump has been or must be exceeded (See Section 3.6), additional cement must be added at the rate of 20 lb per cubic yard per in. of the slump in excess of the maximum slump specified. Otherwise, the overslump concrete may be rejected.

7.7.6 Discharge of the concrete shall ordinarily be completed within 1 ½ hours, or before the drum has revolved 300 revolutions, whichever comes first, after the introduction of any mixing water to the cement and aggregates or the introduction of the cement to the aggregates (ribbon loading). These limitations are waived as outlined in Sections 7.7.7, 7.7.8, and 7.7.9 below.

7.7.7 During the period from September 1st to June 30th and only when the concrete temperature is expected to be below 70°F, discharge may continue even if the limitations noted in 7.7.6 above are exceeded, so long as the concrete is of such slump that it can be placed and consolidated to the satisfaction

of the Supervising Engineer for Concrete Construction or his authorized representative without the addition of any more water in any manner whatsoever to the concrete. Concrete which has stiffened beyond the point of proper placability and consolidation as determined by the Supervising Engineer shall not be retempered and shall be discarded.

7.7.8 During the period from June 30th to September 1st, if concrete is batched at the plant or job site with part of the mixing water in the drum, discharge shall be completed within the limits shown in Table 7.7.8 wherein the elapsed time shall be counted from the time the aggregates and cement are added to the mixer, up to the time of complete discharge of the concrete.

TABLE 7.7.8

Concrete Temperature	Time
90° and over	1 hour or 300 revolutions, whichever comes first
80°F	1 hour 15 minutes or 300 revolutions, whichever comes first
70°F	1 hour 30 minutes or 300 revolutions, whichever comes first

7.7.9 If the concrete is batched and delivered to the job site with no added water in the mixer, the elapsed time from the addition of water to the materials, to the time of complete discharge of the concrete shall not be greater than the values given in Table 7.7.8. These values shall apply between the period of June 30th to September 1st. For the period from September 1st to June 30th and only when the concrete temperature is expected to be below 70°F, discharge may continue as per Section 7.7.7 above. This provision of Section 7.7.7 shall not apply to concrete made with lightweight aggregates which have more than two percent (2 percent) absorption by weight. Such concrete shall be batched, mixed and discharged in accordance with Section 7.6.

7.8 Weather Conditions

7.8.1 Cold Weather

7.8.1.1 To maintain the temperature of the concrete above the minimum placing temperature required by Section 8.6.3 the as-mixed temperature shall not be less than 55°F when the mean temperature falls below 40°F. Follow the detailed recommendations given in "Cold Weather Concreting" (ACI 306R), where applicable.

7.8.1.2 If water or aggregate has been heated above 100°F, the water shall be combined with the aggregate in the mixer before cement is added. Cement shall not be added to mixtures of water and aggregate when the temperature of the mixture is greater than 90°F.

7.8.2 Hot Weather

7.8.2.1 The ingredients shall be cooled before mixing if necessary to maintain the temperature of the concrete below the maximum placing temperature required by Section 8.6.3. The temperature of the concrete at initial discharge shall not exceed 85°F. Follow the detailed recommendations given in "Hot Weather Concreting" (ACI 305R), where applicable.

7.8.3 Under special circumstances, and with written approval of the Supervising Engineer for Concrete Construction, the above provisions as to the initial discharge temperature of the concrete may be modified.

7.8.4 Accelerators or retarders may be used with the approval of the Supervising Engineer for Concrete Construction. When permitted, they shall be used in accordance with "Hot Weather Concreting" (ACI 305R).

7.9 Mixing Small Quantities of Concrete

Only when permitted by the Supervising Engineer for Concrete Construction, small quantities of concrete may be mixed by either a small manually controlled portable mixer or by hand. In such cases, volumetric measurement of aggregates will be permitted.

Concrete shall be hand mixed on a watertight platform. Cement and aggregates shall first be mixed dry until a uniform color is obtained. Water shall then be added and the entire mass turned over at least six times, or until the mixture is uniform and of the required consistency. Not more than one-half cubic yard of concrete shall be hand mixed in any batch.

END OF CHAPTER

NO TEXT ON THIS PAGE

CHAPTER 8 - PLACING

8.1 General

This chapter provides requirements for placing concrete including preparation before placing, conveying, depositing, consolidation, weather protection, bonding, underwater concreting, and placing of grout and mortar.

8.2 Submittals

8.2.1 Shop drawings of placing and constructing methods.

8.2.2 Test and inspection records.

8.2.3 Request for acceptance of preplacement activities and ensure that the preplacement activities are properly inspected.

8.2.4 Advance notification of forthcoming placement. Arrange for tests and inspection to be properly coordinated.

8.2.5 Proposed wet weather protection activities.

8.2.6 Proposed precautions for placement of concrete hotter than 90°F.

8.2.7 Description of conveying equipment.

8.2.8 Proposed method for underwater placement.

8.2.9 Proposed location and treatment of construction joints not shown on the Drawings. Proposed methods for roughening the surface and the use of Portland Cement grout.

8.2.10 Sample finish.

8.2.11 Bonding agents other than cement grout for two course slabs.

8.2.12 Specification and data on proposed chemical retarder.

8.2.13 Proposed location of saw cut joints not indicated on the drawings.

8.2.14 Proposed methods to measure concrete compressive strength by means other than field cured cylinders for termination of curing, such as maturity, penetration resistance, pulse velocity, rebound hammer, or pullout strength.

8.2.15 Proposed method of measure of concrete surface temperature changes.

8.2.16 Proposed methods of curing other than those of Chapter 12.

8.2.17 Description of proposed coated form ties.

8.2.18 Specification and data for any proposed patching material other than Portland Cement mortar described in Section 9.2.2.

8.2.19 Proposed repair method for removal of stains, rust, efflorescence, and surface deposits.

8.2.20 Where new concrete work is to be made integral with existing concrete work, the Contractor shall submit to the Supervising Engineering for Concrete Inspection the proposed procedure for approval.

8.2.21 An accurate record shall be maintained by the Contractor of the dates of concrete placings and the exact location thereof and the dates of removals of forms. This record shall be coordinated with and in addition to those maintained by the Supervising Engineer for concrete inspection.

8.3 Preparation before Placing

8.3.1 Hardened concrete and foreign materials shall be removed from the inner surfaces of the conveying equipment.

8.3.2 Formwork shall have been completed; ice and excess water shall have been removed; reinforcement shall have been secured in place; expansion joint material, anchors and other embedded items shall have been positioned. Concrete shall not be placed on frozen ground.

8.3.3 Semiporous subgrades shall be sprinkled sufficiently to eliminate suction and extremely porous subgrade shall be sealed in an approved manner.

8.3.4 Before placing concrete for a slab on grade, complete the following:

8.3.4.1 Subgrade shall be well drained and of adequate and uniform load bearing nature.

8.3.4.2 In-place density of the subgrade soils shall be at least the minimum required by the Contract Documents.

8.3.4.3 The subgrade shall be free from frost.

8.3.4.4 The subgrade shall be moist with no free water on the subgrade and no muddy or soft spots.

8.3.5 No concrete shall be placed until the entire preparation has been approved by the Supervising Engineer for Concrete Construction or his authorized representative.

8.3.6 When high ambient temperatures necessitate protection of concrete immediately after placing or finishing, make provisions in advance of concrete placement for windbreaks, shading, fogging, sprinkling, ponding, or wet covering with a light colored material.

8.3.7 During cold weather make provisions in advance of concrete placement to maintain the temperature of the concrete as specified in Section 8.5.3.1. Use heating, covering or other means adequate to maintain the required temperature without injury to concrete due to concentration of heat. Do not use combustion heaters during the first 24 hours unless precautions are taken to prevent exposure of the concrete to exhaust gases containing carbon dioxide.

8.3.8 Notify the Engineer at least 24 hours before starting the new concrete placement.

8.4 Conveying

8.4.1 Concrete shall be handled from the mixer to the place of final deposit as rapidly as practicable by methods which will prevent separation or loss of ingredients and in a manner which will assure that the required quality of the concrete is obtained. Follow the detailed recommendations given in "Guide for Measuring, Mixing, Transporting, and Placing Concrete" (ACI 304), where applicable.

8.4.2 Conveying equipment shall be of size and design to insure a continuous flow of concrete at the delivery end and shall be approved. Conveying equipment and operations shall conform to the following requirements:

8.4.2.1 Truck mixers, agitators and nonagitating units and their manner of operation shall conform to the applicable requirements of Chapter 7.

8.4.2.2 Belt conveyors shall be horizontal or at a slope which will not cause segregation or loss. Protect concrete to minimize drying and effects of temperature rise. Use an acceptable discharge hopper at the discharge end to prevent segregation. Do not allow mortar to adhere to the return length of the belt.

8.4.2.3 Chutes shall be metal or metal-lined having rounded bottoms and shall have a slope not exceeding 1 vertical to 2 horizontal and not less than 1 vertical to 3 horizontal. Chutes more than 20 feet long and chutes not meeting the slope requirements may be used provided they discharge into a hopper before distribution.

8.4.2.4 Pump equipment shall be of suitable kind and adequate pumping capacity and shall be subject to approval by the Supervising Engineer for Concrete Construction. Placement shall be controlled so that segregation does not occur in the discharged concrete. Do not convey concrete through pipe made of material containing aluminum. Test cylinders for strength and tests for slump, temperature, and air content shall be made on samples of concrete taken at point of discharge from the pump line.

8.4.2.5 The provisions of paragraph 8.4.2.4 shall apply to placement methods delivering concrete through lines using pneumatic air pressure.

8.4.2.6 The provisions of paragraphs 8.4.2.4 and 8.4.2.5 are not applicable to gunned mortar applications.

8.5 Depositing

8.5.1 Concrete shall be deposited continuously, or in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously, construction joints shall be located at points as provided for in the drawings or as approved. Placing shall be carried on at such a rate that the concrete which is being integrated with fresh concrete is still plastic. Concrete which has partially hardened or has been contaminated by foreign materials shall not be deposited. Temporary spreaders in forms shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. They may remain embedded in the concrete only if made of metal or concrete and if prior approval has been obtained. Detailed recommendations are given in "Guide for Measuring, Mixing, Transporting, and Placing Concrete" (ACI 304), where applicable.

8.5.2 Placing of concrete in supported elements shall not be started until the concrete previously placed in columns and walls is no longer plastic and has been in place at least two hours.

8.5.3 Concrete shall be deposited as nearly as practicable in its final position to avoid segregation due to rehandling or flowing. Concrete shall not be subjected to any procedure which will cause segregation.

8.5.4 Place concrete for beams, girders, brackets, column capitals, haunches, and drop panels at the same time as concrete for slabs.

8.5.5 When underwater placement is required or permitted, place concrete by a method acceptable to the Engineer. Deposit the fresh concrete so the concrete enters the mass of the previously placed concrete from within, displacing water with a minimum disturbance to the surface of the concrete.

8.5.6 Where a surface mortar is to be the basis of the finish, the coarse aggregate shall be worked back from the forms with a suitable tool so as to bring a full surface of mortar against the form, without the formation of excessive surface voids. All concrete shall be consolidated by internal vibration, spading, rodding, or forking so that the concrete is thoroughly worked around the reinforcement, around embedded items and into corners of forms, eliminating all air or stone pockets which may cause honeycombing, pitting or planes of weakness. Use internal vibrators of the largest size and power that can properly be used in the Work as described in Table 8.4.6. Overvibrating and use of vibrators to transport concrete within forms shall not be allowed. Vibrators shall be inserted and withdrawn at many points, approximately 18 in. apart. At each insertion, the duration shall be sufficient to consolidate the concrete but not sufficient to cause segregation, generally from 5 to 15 sec. duration. A spare vibrator shall be kept on the job site during all concrete placing operations. Follow the detailed recommendations given in "Consolidation of Concrete" (ACI 309R), where applicable. Workers shall be experienced in use of the vibrators.

TABLE 8.5.6 - RANGE OF CHARACTERISTICS, PERFORMANCE, AND APPLICATIONS OF INTERNAL VIBRATORS

Column (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			Suggested Values of			Approximate values of		
Group	Diameter of head in. (mm)	Recommended frequency, vibrations per min (Hz)	Eccentric moment in-lb. (mm-N)	Average amplitude in. (mm)	Centri-fugal force lb (kN)	Radius of action in.(mm)	Rate of concrete placement, cu.yd. per hr. per vibrator(m3/hr)	Application
1	3/4-1 ½ (20-40)	10,000-25,000 (170-250)	0.03-0.10 (0.34-1.1)	0.015-0.03 (0.4-0.8)	100-400 (0.5-1.8)	3-6 (80-150)	1-5 (0.8-4)	Plastic and flowing concrete in very thin members and confined places.
2	1 1/4-2 ½ (30-60)	9,000-13,500 (150-225)	0.08-0.25 (0.9-2.8)	0.02-0.04 (0.5-1.0)	300-900 (1.4-4.0)	5-10 (130-250)	3-10 (2.3-8)	Plastic concrete in thin walls, columns, beams, precast piles, thin slabs, and along construction joints.
3	2-3 ½ (50-90)	8,000-12,000 (130-200)	0.20-0.70 (2.3-7.9)	0.025-0.05 (0.6-1.3)	700-2,000 (3.1-8.9)	7-14 (180-360)	6-20 (4.6-15)	Stiff plastic concrete (less than 3 in. (75 mm) slump) in general construction such as walls, columns, beams, prestressed piles, and heavy slabs.
4	3-6 (80-150)	7,000-10,500 (120-180)	0.70-2.5 (7.9-28.3)	0.03-0.06 (0.8-1.5)	1500-4000 (6.7-18)	12-20 (300-510)	15-40 (11-31)	Mass and structural concrete of 0 to 2 in (50 mm) slump deposited in quantities up to 4 cu.yd. (2m3) in relatively open forms of heavy construction.
5	5-7 (130-180)	5,500-8,500 (90-140)	2.25-3.50 (25.4-39.5)	0.04-0.08 (1-2)	2500-6000 (11-27)	16-24 (400-610)	25-50 (19-38)	Mass concrete in gravity dams, large piers, massive walls, etc.

NOTES TO TABLE 8.5.6

Column 3 - While vibrator is operating in concrete.

Column 4 - Computed eccentric moment = ef, in-lb (mm-N), where e = distance from center of gravity of eccentric to its center of rotation, in (mm) and f = force of gravity of the eccentric, lb (N).

Column 5 - Measured or computed peak amplitude while operating in air (deviation from point of rest), a = ew/(W + w), in (mm), where W = mass of shell and other non-moving parts, lb (kg) and w = mass of eccentric, lb (kg).

Column 6 - Computed centrifugal force of vibrator, F = 4 new/g, lb, (kN), where n = frequency of vibrator while operating in concrete, cycles per sec (Hz) and g = acceleration of gravity, 386.1 in/s (9806 mm/s).

Column 7 - Radius over which concrete is fully consolidated.

Column 8 - Assumes insertion spacing is 1-1/2 times the radius of action, and that vibrator operates two-thirds of time concrete is being placed.

Column 7&8 - These ranges reflect the capability of vibrator, mix workability, degree of deviation desired, and other construction conditions.

8.5.6.1 External vibration shall only be used when explicitly permitted by the Supervising Engineer for Concrete Construction. Vibrating operations shall be continuous throughout the entire section where concrete is being deposited. Vibrators shall be clamped to the studs or wales or in pairs so that while one is vibrating the other can be shifted to insure constant vibration. External vibration shall conform to the requirements of ACI 309R.

8.5.7 Self-supporting floors and roofs.

8.5.7.1 Reinforced Concrete Beams and Girders shall be cast monolithically with adjoining arches.

8.5.7.2 Canopies, Cornices and Marquees shall be monolithically cast with floor arches, with profiles true to indicated contours. Top surfaces of canopies and marquees shall be pitched to drain. Exposed soffits and edges shall be rubbed with carborundum stone and left clean and true.

8.6 Protection, Weather, Placing and Preparation of Forms.

8.6.1 Concrete placed during rain, sleet or snow, or when the mean daily temperature falls below 40°F or is expected to be below 40°F during placing or within 24 hours thereafter or rises above 90°F shall be adequately protected as provided in Chapter 12 and approval for placement shall be obtained from the Supervising Engineer for Concrete Construction.

8.6.2 Rain water shall not be allowed to increase the mixing water nor to damage the surface finish.

8.6.3 Placing temperature.

8.6.3.1 When the mean daily temperature falls below 40°F, the minimum temperature of concrete as placed shall be 50°F. Follow the detailed recommendations given in "Cold Weather Concreting" (ACI 306R), where applicable.

8.6.3.2 Concrete deposited in hot weather shall have a placing temperature which will not cause difficulty from loss of slump, flash set, or cold joints. The temperature of the concrete preferably should be less than 80°F and shall not exceed 90°F unless permitted by the Supervising Engineer for Concrete Construction. Loss of slump, flash set, or cold joints due to the temperature of the concrete as placed will not be acceptable. When the temperature of the steel is greater than 120°F, fog the steel forms and the reinforcement with water just prior to placing the concrete. Follow the detailed recommendations given in "Hot Weather Concreting" (ACI 305R), where applicable.

8.6.4 Placing.

8.6.4.1 Adequate skilled personnel and equipment shall be available to handle and place the concrete immediately upon delivery.

8.6.4.2 Dry surfaces shall be wet down before commencing placement of concrete.

8.6.4.3 Temperature of surfaces to receive concrete (earth, forms, reinforcing steel, etc.), should approximate the temperature of the concrete being placed.

8.6.4.4 Evaporation rate of water from freshly placed concrete should be held to a minimum by:

(a) Shading of operations.
(b) Reducing air circulation in area of operations.
(c) Maintaining fog spray during operations.

8.6.4.5 Cold Joints shall be avoided. This can be accomplished by:

(a) Providing adequate skilled personnel to handle and place the concrete immediately after its delivery to the forms at an acceptable temperature.

(b) Placing in layers thin enough and areas small enough so that vibration or working of the concrete will insure complete union of adjacent layers.

(c) Lengthening of setting time by use of approved water reducing retarders.

(d) Placing a bulkhead at a suitable point where placement is stopped temporarily.

8.6.4.6 Loss of slump shall be kept at a minimum. This can be accomplished by:

(a) Minimum lapse of time between mixing and placing.

(b) Avoiding delays in batch mixing and truck dispatching.

(c) Job conditions and equipment (chutes, access runs, etc) being organized to prevent additional mixing.

(d) Use of approved water reducing retarders.

8.6.5 Preparation of forms.

All forms or surfaces (subgrades, reinforcing steel) to receive concrete, in addition to the normal requirements of tightness, soundness, being free of debris, etc., shall be:

8.6.5.1 Protected against excessive air currents.

8.6.5.2 Sprinkled systematically with cool water.

Note: Wetting down around the work will cool the surrounding air and increase the humidity, thus reducing temperatures and evaporation from the concrete.

8.7 Bonding

8.7.1 When specified, the surface of joints shall be prepared in accordance with Section 6.3.

8.7.2 The hardened concrete of joints between footings and walls or columns, between walls or columns and beams or floors they support, joints in unexposed walls and all other not mentioned below shall be dampened (but not saturated) immediately prior to placing of fresh concrete.

8.7.3 The hardened concrete of horizontal construction joints in exposed work; horizontal construction joints in the middle of beams, girders or joints, and slabs; and horizontal construction joints in work designed to contain liquids shall be dampened (but not saturated) then thoroughly covered with a coat of neat cement mortar of similar proportions on vertical surfaces and at least ½ in. thick on horizontal surfaces. The fresh concrete shall be placed before the mortar has attained its initial set.

8.7.4 Joints receiving an adhesive shall have been prepared and adhesive applied in accordance with the manufacturer's recommendations prior to placing of fresh concrete.

8.7.5 Surfaces of joints which have been obtained by the use of a chemical retarder shall have been prepared in accordance with the manufacturer's recommendations prior to placing of fresh concrete.

8.8 Concreting Under Water

8.8.1 Placing concrete in water will be permitted only when approved by the Supervising Engineer for Concrete Construction. Concrete deposited under water shall be carefully placed in a compacted mass in final position by means of a tremie, a closed bottom dump bucket or other approved means, and shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. Concrete shall not be placed in running water. Underwater formwork shall be reasonably watertight. The consistency of the concrete shall be carefully regulated and special care shall be exercised to prevent segregation of materials. The method of depositing concrete shall be regulated to produce approximately horizontal surfaces.

8.8.2 When a tremie is used, it shall consist of a tube having a diameter of not less than 10 in. and constructed in sections having flanged couplings fitted with gaskets. The tremie shall be supported to permit free movement of the discharge end over the entire top surface of the work and shall permit rapid lowering when necessary to choke off or retard the flow. The discharge end shall be entirely sealed at all times and the tremie tube kept full to the bottom of the hopper. When a batch is dumped into the hopper, the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. The flow shall then be stopped by lowering the tremie. The flow shall be continuous until the pour has been completed.

8.8.3 When a bucket is used to place concrete in water, it shall have a capacity of not less than ½ cubic yard.

8.9 Protection and Cleaning of Exposed Structural Steel.

8.9.1 The Contractor shall take all necessary precautions to prevent mortar and concrete splashes on the steel. The Contractor shall exercise care to prevent abrasion or scuffing of the paint on the structural steel while concrete is being formed, placed or stripped.

8.9.2 The Contractor shall thoroughly clean the structural steel of all concrete drippings or other foreign matter that may have been deposited on the steel or on any other part of the structure as a result of his operations. All the work involved in thoroughly cleaning the steel shall proceed before concrete drippings have hardened. Immediately after the concrete has been placed, the Contractor shall clean the steel with water and/or such other additional means subject to the approval of the Supervising Engineer for Concrete Construction as may be necessary to remove all mortar, concrete and other foreign matter that has been dropped, dripped, splashed or otherwise deposited on the steel as a result of his operations. It will be the contractor's obligation and responsibility to remove all foreign matter to the satisfaction of the Supervising Engineer for Concrete Construction.

8.9.3 After formwork has been removed, any concrete or other foreign material that may have been previously missed and that still remains on the steel shall be removed.

8.10 Grout and Mortar

8.10.1 Grout and mortar materials shall be in accordance with Section 3.10 except as noted in 8.10.2.

8.10.2 Clearances into which the grout and/or mortar is to be placed shall preferably be not less than 1 in. and not more than 6 in. Where clearances are from 3 to 6 in. in depth, pea gravel (1/4 to 3/8 in.) shall be added provided it does not prevent proper placement.

8.10.3 Concrete surfaces to receive the grout and/or mortar shall be rough, clean, free of laitance, oil and grease. Before application of the grout the surface of the concrete should be thoroughly wetted but with no free standing water on same.

8.10.4 Pressure grouting consists in forcing a fluid cement water paste with or without admixtures and fine sand into locations such as cracks in foundations, joints between sections of a structure, embedded items, etc. The grout mixture shall be applied under such pressure and at such consistency as will insure complete filling of voids.

8.10.5 Non-shrink grout.

8.10.5.1 Mixing, placing, finishing, and curing shall be strictly in accordance with manufacturer's instructions. When required in the detailed specifications, the contractor shall have a specially trained technician furnished by the manufacturer from his full-time staff at the job-site when the work is started and at such other times as his service is required.

8.10.5.2 Forms shall be high enough to provide a minimum of 2 in. of head to maintain contact of the fluid grout with the undersides of horizontal surfaces while the grout is hardening and to retain the grout without movement until after final set.

8.10.5.3 Placing shall be rapid and continuous to avoid the undesirable consequences of over working and breakdown of initial set. Grout shall be placed from only one side or one end to avoid air entrapment. Retempering shall not be permitted. A stiff wire moved back and forth in the grout will help release entrapped air, distribute the grout and assure more complete contact.

8.10.5.4 During cool weather, the temperature of the grout in place shall be maintained at 65°F or above until after final set by heating the components of the grout before mixing and by heating the item to be grouted together with the base concrete in advance of and during the operation by the use of infrared or other heating equipment and/or protective enclosures. All such measures shall be subject to the approval of the Supervising Engineer for Concrete Construction.

8.10.5.5 During warm weather, bed plates and the like shall be wet down, covered with wet burlap or otherwise cooled and shaded to reduce temperatures to below 80°F prior to grouting and until final set. The grouting material and/or the mixing water shall be sufficiently cool to provide a grout temperature under 80°F when placed.

8.10.5.6 After the non-shrink grout has acquired final set, all unconfined grout shall be cut back.

8.10.5.7 After non-shrink grout has attained its final set, it shall be cured above 50°F for a minimum of 24 hours and above 40°F for 28 days.

8.11 Grouting and Protection of Various Bases

8.11.1 Pressure grouting as defined in Section 8.9.4 shall be used to fill all spaces between steel sash and frames with the surrounding construction. All buffer channels and floor saddles for elevators, etc., shall be grouted in solid.

8.11.2 All steel column baseplates, bearing plates and similar items of structural steel shall be grouted or dry packed immediately after their erection. Bases, etc. with least dimension of twenty-four in. (24") or less may be dry packed (Section 3.10.3) or grouted with a non-shrink grout (Section 3.10.2). Bases, etc. with least dimension greater than 24 in. shall be grouted with a non-shrink grout (Section 3.10.2).

8.11.3 Machine and equipment bases shall be grouted or dry packed when and as recommended by the manufacturer. Unless otherwise designated in the detailed specifications, bases with least dimension of twenty-four (24) in. or less may be dry packed (Section 3.10.3) or grouted with a non-shrink grout (Section 3.10.2). Bases with least dimension greater than 24 in. shall be grouted with a non-shrink grout. Care must be exercised that the grout reaches under all areas. When placing is to be done from the side of a machine base and grout is to be placed at a higher level than the lower edge of the bed plate, it shall be necessary to provide holes in the base plate to permit the filling with grout and also to provide a vent in each recess so that air can escape. If holes are not provided by the manufacturer, small holes, 3/8 in. or ½ in. in diameter shall be bored in the bed plate for this purpose after approval is obtained from the equipment manufacturer.

END OF CHAPTER

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CHAPTER 9 - REPAIR OF SURFACE DEFECTS

9.1 General

All repairable defective areas shall be patched immediately after form removal.

9.2 Submittals

9.2.1 Detailed repair procedures for defective concrete including use of Portland cement mortar, shotcrete, or other commercial patching products.

9.2.2 Materials and procedures to be used to plug tie holes, other than for Portland cement mortar.

9.2.3 Methods to be used to remove stains, rust, efflorescence, and surface deposits.

9.3 Repair of Defective Areas

9.3.1 Repair with Portland cement mortar.

9.3.1.1 Outline all honeycombed or otherwise defective concrete with a ½ to 3/4 in. deep saw cut and remove such concrete down to sound concrete. If chipping is necessary the edges shall be perpendicular to the surface or slightly undercut. No feather edges will be permitted. The area to be patched and area at least 6 in. wide surrounding it shall be dampened to prevent absorption of water from the patching mortar. A bonding grout shall be prepared using a No. 30 mesh sieve, mixed to the consistency of thick cream, and then well brushed into the surface.

9.3.1.2 The patching mixture shall be made of the same materials and of approximately the same proportions as used for the concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of not more than 1 part cement to 2 ½ parts sand by damp loose volume. White Portland cement shall be substituted for a part of the gray Portland cement on exposed concrete to produce a color matching the color of the surrounding concrete, as determined by a trial patch. The quantity of mixing water shall be no more than necessary for handling and placing. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel, without addition of water, until it has reached the stiffest consistency that will permit placing.

9.3.1.3 After the surface water has evaporated from the area to be patched, the bond coat shall be well brushed into the surface. When the bond coat begins to lose the water sheen, the premixed patching mortar shall be applied. The mortar shall be thoroughly consolidated into place and struck off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, it shall be left undisturbed for at least 1 hour before being finally finished. The patched area shall be kept damp for 7 days. Metal tools shall not be used in finishing a patch in a formed wall which will be exposed.

9.3.2 Repair material and procedures other than those specified in 9.3.1 may be used for repair when acceptable. Materials include but are not limited to:

9.3.2.1 Shotcrete

9.3.2.2 Commercial patching products, including:

(a) Portland cement mortar modified with a latex bonding agent conforming to ASTM C1059 Type II.

(b) Epoxy mortars and compounds that are moisture insensitive with an epoxy binder that conforms to ASTM C881, Type III.

Caution shall be exercised when using these materials with regard to possible color changes from weathering, and delamination due to different coefficients of thermal expansion.

9.3.3 When required for exposed concrete that will be left unpainted, color tests shall be made with patching methods and material to determine color compatibility.

9.4 Tie Holes

Tie holes shall be plugged immediately after form removal unless stainless steel, noncorrosive, or acceptably coated ties are use. When Portland cement mortar is used for plugging, tie holes shall be cleaned and dampened prior to patching. When the surface is to be textured for architectural appearance by sandblasting or bushhammering, minor defects and tie holes shall be repaired to match the adjoining concrete in color and texture when viewed from a distance of 15 ft. Other materials used for plugging the holes shall be subject to acceptance by the Supervising Engineer for Concrete Construction and shall be applied in accordance with the manufacturer's written recommendations, where applicable.

9.5 Removal of Stains, Rust, Efflorescence, and Surface Deposits

Stains, rust, efflorescence, and surface deposits considered objectionable by the Supervising Engineer for Concrete Construction shall be removed by methods acceptable to the Supervising Engineer for Concrete Construction.

END OF CHAPTER

CHAPTER 10 - FINISHING OF STRUCTURAL CONCRETE FORMED SURFACES

10.1 General

10.1.1 These requirements shall apply to finishes of concrete surfaces which will be covered, or will be exposed to view in areas not requiring Architectural concrete finishes as described in Chapter 13. Such surface finishes as may be used for basement walls, ceilings, closets, pipe shafts, utility rooms, columns, beams, girders, curbs, etc. will be considered in this category unless otherwise shown or specified.

10.1.2 After removal of forms, the surface of the concrete shall be given one more of the finishes specified below in locations designated by the project drawings and/or the detailed specifications or as specified in Section 10.5.

10.2 Submittals

10.2.1 Use of alternate materials other than specified in Section 10.3.2 for smooth form finish, if applicable.

10.3 As-cast Finishes

10.3.1 Rough or board form finish surfaces shall be reasonably true to line and plane with no specific requirements for selected facing materials. Tie holes and defects shall be patched and fins exceeding 1/4 in. in height shall be removed. Otherwise, surfaces shall be left with the texture imparted by the forms.

10.3.2 Smooth form finish - finish shall be produced in the same manner as rough or board form finish, except as follows:

10.3.2.1 Concrete shall be cast against forms constructed of plywood not less than 5/8 in. thick or of boards lined with tempered hardboard not less than 3/16 in. thick. Other materials capable of producing the desired result may be used subject to the approval of the Supervising Engineer for Concrete Construction.

10.3.2.2 The arrangement of plywood sheets or liner sheets shall be orderly and symmetrical, and sheets shall be in as large sizes as are practicable.

10.3.2.3 Sheets showing torn grain, worn edges, patches of holes from previous use, or other defects which will impair the texture of concrete surfaces shall not be used.

10.3.2.4 All fins on the surface shall be completely removed.

10.3.3 Special finishes-Textured form finish, special panel finish, exposed aggregate finish are Architectural concrete finishes and shall be produced in accordance with the requirements of Chapter 13 (Architectural Concrete).

10.4 Rubbed Finishes

The following finishes shall be produced on concrete which has been cast against plywood or other smooth surface form material.

10.4.1 Smooth Rubbed Finish - Produce finish on newly hardened concrete no later than the day following form removal. Wet the surface and rub it with carborundum brick or other abrasive until uniform color and texture are produced. Use no cement grout other than the cement paste drawn from the concrete itself by the rubbing process.

10.4.2 Grout Cleaned Finish

10.4.2.1 As soon as practical, but no later than one week, after the forms are removed, the concrete shall be patched, fins removed, and tie holes filled as required.

10.4.2.2 When the entire surface is ready for final finishing, the surface shall be thoroughly cleaned; oil, rust stains, paint or other discolorations that will interfere with the final finish shall be removed. The surface shall be predampened and a cement slurry consisting of 1 part cement (including an appropriate quantity of white cement) and 1 ½ part of sand passing the No. 30 sieve, by damp loose volume, shall be spread over the surface with clean burlap pads or sponge rubber floats and scrubber into the surface with a rotary motion. Any surplus material shall be removed by scraping and then rubbing with clean burlap. The finish shall be cured, by keeping the surface damp for 36 hours afterward.

10.4.3 Cork Floated Finish

10.4.3.1 Remove forms at an early stage, within 2 to 3 days of placement where possible. Remove all burrs and fins. Mix one part Portland cement and one part fine sand with sufficient water to produce a stiff mortar. Dampen wall surface. Apply mortar with firm rubber float or with trowel, filling all surface voids. Compress mortar into voids using a slow speed grinder. If the mortar surface dries too rapidly to permit proper compaction and finishing, apply a small amount of water with a fog sprayer. Produce the final texture with a cork float using swirling motion.

10.5 Unspecified Finish

Unless selection of finishes is made in the detailed specifications, the following finishes shall be used as applicable:

10.5.1 Rough or board form finish (Section 10.3.1) - for all concrete surfaces not exposed to public view, including concrete in utility spaces.

10.5.2 Smooth rubbed finish (Section 10.4.1) - for all other exterior surfaces and interior vertical surfaces, and all exposed surfaces to be painted.

10.5.3 Plywood Smooth Form finish (Section 10.3.2) - for all other interior overhead surfaces exposed to public view.

10.6 Related Unformed Surfaces

Tops of walls or buttresses, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces shall be struck smooth after concrete is placed and shall be floated to a texture reasonably consistent with that of formed surfaces. Final treatment on formed surfaces shall continue uniformly across the unformed surfaces.

END OF CHAPTER

CHAPTER 11 - SLABS

11.1 General

11.1.1 Concrete for slabs shall be proportioned in accordance with Chapter 3 and the detailed specifications.

11.1.2 These requirements shall apply to all types of concrete work including where the surface is intended to received floor covering, light and heavy duty wearing courses, insulation, roofing, waterproofing membranes, paving brick, tile or terrazzo.

11.2 Submittals

11.2.1 Construction Joints - Submit information on proposed location and treatment of any construction joints needed but not indicated on the Contract Drawings.

11.2.2 Two-Course Slabs - If a bonding agent other than cement grout is proposed, submit specification and data for bonding agent.

11.2.3 Exposed Aggregate Surface - If an exposed aggregate surface is specified and a chemical retarder is proposed, submit specification and data for retarder.

11.2.4 Saw Cut Joints - If saw cut joints other than those indicated on the Contract Drawings are needed, submit request for location.

11.3 Performance and Design Requirements

Construction Joints - Make and locate any construction joints needed, but not indicated on the Contract Drawings, without impairing the strength of the structure and in accordance with 4.3.9.

11.4 Slabs on Ground

11.4.1 These requirements shall also apply to any concrete work intended for use as pavements, sidewalks, slabs on grade, platforms, steps, landings and other walking or riding surfaces, except as modified by Chapter 19 (slabs on earth, curbs and drainage structures).

11.5 Edge Forms and Screeds

11.5.1 Edge forms and intermediate screed strips shall be set accurately to produce the designed elevations and contours in the finished surface, and shall be sufficiently strong to support vibrating bridge screeds or roller pipe screeds if the nature of the finish specified requires the use of such equipment. The concrete surface shall be aligned to the contours of screed strips by the use of strike-off templates or approved compacting type screeds.

11.5.2 When the formwork is cambered, screeds shall be set to a like camber to maintain the proper concrete thickness.

11.6 Placement

11.6.1 Mixing and placing shall be carefully coordinated with finishing. Concrete shall not be placed on the subgrade in forms more rapidly than it can be spread, straight edged, and darbyed or bull-floated. These operations must be performed before bleeding water has an opportunity to collect on the surface.

11.6.2 To obtain good surfaces and avoid cold joints, the size of the finishing crews shall be planned with due regard for the effects of concrete temperature and atmosphere conditions on the rate of hardening of the concrete. If construction joints become necessary, they shall be constructed as required in Chapter 6.

11.7 Jointing

Unless otherwise shown, detailed or specified joints in slabs on grade shall be located and detailed as specified in Chapter 19, Section 19.5. If saw-cut joints are required or permitted, cutting shall be timed properly with the set of concrete. Cutting shall be started as soon as the concrete has hardened sufficiently to prevent aggregates being dislodged by the saw, and shall be completed before shrinkage stresses have developed sufficiently to induce cracking.

11.8 Consolidation

Concrete in slabs shall be thoroughly consolidated. Internal vibration shall be used in beams and girders of framed slabs and along the bulkheads of slabs on grade. Consolidation of slabs and floors shall be obtained with vibrating screeds, roller pipe screeds, or other approved means. Concrete to be consolidated shall be as dry as practicable and the surfaces thereof shall not be manipulated prior to finishing operations. Conform with requirements of Section 8.5.6.

11.9 Finishing Unformed Surfaces

11.9.1 Placement - Place concrete at a rate that allows spreading, straight edging, and darbying or bull-floating before bleed water appears. Strike smooth the top of walls, buttresses, horizontal offsets, and other similar unformed surfaces and float them to a texture consistent with finish of adjacent formed surface. Finish slab surfaces in accordance with one of the finishes in 11.9.2 - Finishes, as designated in the Contract Documents.

11.9.2 Finishes

11.9.2.1 Scratched Finish - After the concrete has been placed, consolidated, struck off, and leveled, roughen the surface with stiff brushes or rakes before final set.

11.9.2.2 Floated Finish - After the concrete has been placed, consolidated, struck off, and leveled, do not work the concrete further until it is ready for floating. Begin floating with a hand float, a bladed power float equipped with float shoes, or a powered disc float as soon as the water sheen has disappeared and the surface has stiffened sufficiently to permit the operation. During or after the first floating, check flatness of surface with a 10 ft straightedge applied in two or more directions. Eliminate high spots and low spots during this procedure to produce a conventional, straightedge finish, then refloat the slab immediately to a uniform texture. Leveling and flatness of tank floors shall be as described in the Detailed Specifications.

11.9.2.3 Troweled Finish - Float finish the concrete surface first, then power trowel the surface. Finally, hand trowel the surface smooth and free of trowel marks. For surfaces specified as being exposed to wear,

continue hand troweling until a ringing sound is produced as the floor is troweled. Tolerance for concrete floors on metal deck shall be conventional, straightedge; tolerance for other types of floors shall be flat. Concrete surfaces intended to support floor coverings shall not have defects that will reflect through the floor covering.

11.9.2.4 Broom or Belt Finish - Immediately after the concrete has received a float finish, give the concrete surface a coarse transverse scored texture by drawing a broom or burlap belt across the surface.

11.9.2.5 Dry-Shake Finish - Blend the metallic or an approved mineral aggregate with Portland cement in the proportions recommended by the aggregate manufacturer, or use acceptable bagged premixed material as recommended by the manufacturer. Float finish the concrete surface. Apply approximately two-thirds of the blended material required for coverage to the surface by a method that ensures even coverage without segregation. Float finish the surface after application of the first dry shake. Apply the remaining dry-shake material at right angles to the first application and in locations necessary to provide a minimum density. Begin final floating and finishing immediately after application of the "dry-shake". After selected material is embedded by the two floatings, complete operation with a broomed, floated, or troweled finish, as designated in the Contract Documents.

11.9.2.6 Heavy-Duty Topping for Two-Course Slabs - For the heavy-duty topping mix use materials specified in the Contract Documents. Place and consolidate concrete for the base slab, and screed the concrete the specified depth below the top of the finished surface.

Topping placed the same day as the base slab may be placed as soon as the bleed water in the base slab has disappeared and the surface will support a person without appreciable indentation.

If topping placement is deferred, brush the surface with a coarse wire broom to remove laitance and scratch the surface. Wet cure the base slab a minimum of three days. Before placing the topping, clean the base slab surface thoroughly of all contaminants, and dampen the surface leaving the surface free of standing water.

Immediately before placing topping, scrub into the slab surface a coat of bonding grout consisting of equal parts of cement and fine sand with enough water to make a creamy mixture. Do not allow the grout to set or dry before the topping is placed. Bonding agents other than cement grout may be used with prior acceptance.

Spread, compact, and float the topping mixture; check for trueness of surface; and float, trowel, or broom finish as specified.

11.9.2.7 Topping for Two-Course Slab Not Intended for Heavy-Duty Service - Preparation of base slab, selection of topping material, mixing, placing, consolidating and finishing operations shall be as specified in Section 11.9.2.6 - Heavy-Duty Topping for Two-Course Slabs, except that the aggregate need not be selected for special wear resistance.

11.9.2.8 Non-Slip - Where a non-slip finish is required, give the surface a broom or belt finish or a "dry-shake" application of crushed aluminum oxide or other acceptable abrasive particles. The rate of application shall be not less than 25 lb per 100 ft.

11.9.2.9 Exposed Aggregate Finish - Immediately after the surface of the concrete has been leveled to a conventional, straightedge tolerance and the bleed water has disappeared, spread aggregate of the color and size specified in the Contract Documents uniformly over the surface to provide complete coverage to

a depth of one stone.

Tamp the aggregate lightly to embed aggregate in the surface. Float the surface until the embedded stone is fully coated with mortar and the surface has been brought to a true plane within a conventional, straightedge tolerance. After the matrix has hardened sufficiently to prevent dislodgement of the aggregate, apply water carefully and brush the surface with a fine bristle brush to expose the aggregate without dislodging the aggregate.

An acceptable chemical retarder sprayed onto the freshly floated concrete surface may be used to extend the working time for the exposure of aggregate.

11.9.2.10 Nonspecified Finish. When the type of finish is not specified in the Contract Documents, use one of the following appropriate finishes and accompanying tolerances.

(a) Scratched Finish. For surfaces intended to receive bonded cementitious mixtures.

(b) Floated Finish. For walks, drives, steps, ramps, and for surfaces intended to receive waterproofing, roofing, insulation, or sand-bed terrazzo.

(c) Troweled Finish. For floors intended as walking surfaces; floors in manufacturing, storage, and warehousing areas; or for reception of floor coverings.

(d) Broom or belt finish. For sidewalks, garage floors, and ramps.

(e) Nonslip finish. For exterior platforms, steps, and landings; and for exterior and interior ramps.

(f) Two-course heavy-duty topping (placed same day or within 24 hours after base slab). For industrial floors.

11.9.3 Finishing Tolerances for Slabs

11.9.3.1 Finish floor slabs to meet the requirements of ACI 117. Measure floor finish tolerances within 72 hours after slab finishing.

11.9.3.2 Unless the Contract Documents specify otherwise, measure floor tolerances in accordance with ASTM E1155.

11.9.4 Finish tolerances shall not be measured across construction joints or within 2 ft of any boundary, well, penetration or similar discontinuity.

11.9.5 Where saw cut joints are required or permitted, start the cutting as soon as the concrete has hardened sufficiently to prevent dislodgement of aggregates. Saw a continuous slot to a depth of one-fourth the thickness of the slab but not less than one inch. Complete sawing within 12 hours after placement such that shrinkage stresses do not produce cracking.

11.9.6 Finishing tolerances for tank floors shall be as described in the Detail Specifications.

11.10 Pitch to Drains

At floor drains, finish shall slope up and away from drains in order to form proper pitch to the drains, as indicated or directed by the Supervising Engineer for Concrete Construction.

11.11 Special Treatments

11.11.1 Special treatments of finished, exposed slabs (painting, hardeners and/or dustproofing) shall be as required in the detailed specifications except that if no special treatment is so specified, then all interior floor areas subject to walking or vehicular traffic shall be given an approved hardening and dustproofing treatment.

11.11.2 Hardener and Dustproofer Application

11.11.2.1 Hardener and dustproofing material shall be applied to all exposed concrete floors, cement finish floors and ramps, stair treads and platforms and cement bases.

11.11.2.2 All surfaces to receive the treatment shall be given a final cleaning. This cleaning shall consist of removing all foreign material including cement and plaster and paint in such a manner that same will not show through the finished surface.

11.11.2.3 The mixture shall be applied in two flooding coats of such consistency as to thoroughly and uniformly saturate the floors and secure the necessary penetration.

11.11.2.4 The mixtures shall be flooded on with a wide brush and allowed to penetrate into the pores of the cement after which they are to be brushed out thoroughly to eliminate any surplus material. The second coat shall be applied in the same manner and finished by being brushed out to eliminate as much of the film coat as is possible. The result of the finished application must be a transparent appearance. Dustproofing compounds shall be applied under the supervision of the representatives of the manufacturer.

11.11.2.5 All surfaces treated shall be subjected to an abrasion test under the use of a stiff steel brush, and must not dust, but polish without showing abrasion.

11.11.2.6 The finished work shall be guaranteed by the manufacturer to be dustproof and oil proof for a period of five (5) years. This guarantee shall be in a form specified under Article on "GUARANTEES" of the "General Conditions Governing All Contracts."

11.11.2.7 Hardener and dustproofing material shall consist of vegetable oils, gums and grey pigments (ground in oil) mixed with thinners on the job site in combinations to meet the conditions of the particular area to be treated. It shall have a penetration of at least one-eight (1/8) of an inch and shall dry hard, forming a dust-proof surface impervious to oil and water. The material shall have been in use for at least five (5) years and all compounds to be included into this floor hardener shall be delivered to the job site in the original containers bearing the manufacturer's label.

END OF CHAPTER

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CHAPTER 12 - CURING AND PROTECTION

12.1 General

All freshly deposited concrete shall be protected from premature drying and excessively hot or cold temperatures, and shall be maintained with minimal moisture loss at a relatively constant temperature for the period of time necessary for the hydration of the cement and proper hardening of the concrete.

12.2 Submittals

12.2.1 Wet Weather Placement - If placement during wet weather is needed, submit request for acceptance of protection.

12.2.2 Hot Weather Placement - If placement of concrete which is hotter than 90°F is needed, submit request for placement along with proposed precautions.

12.2.3 Temperature Measurement - Submit proposed method of measuring concrete surface temperature changes for acceptance.

12.2.4 Moisture-Preserving Method - If a moisture-preserving method other than specified in 12.2.4.1 through 12.4.4.5 is proposed, submit request for acceptance of the proposed method.

12.3 Materials

Curing Compounds - Use curing compounds that conform to ASTM C309.

12.4 Preservation of Moisture

12.4.1 General. Beginning immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury. Meet the minimum curing and protection temperatures of ACI 306.1. Cure in accordance with 12.4.2 or 12.4.3 for at least the first 7 days after placement for all concrete except high early strength concrete, for which the period shall be at least the first 3 days after placement.

Alternatively, moisture retention measures may be terminated when:

(a) Tests are made of cylinders kept adjacent to the structure and cured by the same methods and reach 70 percent of the specified compressive strength, f'c as determined in accordance with ASTM C39.

(b) The temperature of the concrete is maintained at 50°F or higher for the length of time required to achieve 85 percent of f'c in laboratory-cured cylinders that are representative of the concrete in place.

(c) The strength of concrete reaches f'c as determined by accepted nondestructive methods meeting the requirements of Chapter 18.

If one of the curing procedures in 12.4.4, Preservation of Moisture, is used initially, the curing procedure may be replaced by one of the other procedures any time after the concrete is one day old, provided the concrete is not permitted to become surface dry during the transition. When required in the opinion of the

Engineer, use a curing procedure of 12.4.4 that supplies additional water.

During and immediately following curing, do not allow the surface of the concrete to change temperature more than 50°F in any 24-hour period, except as allowed in ACI 306.1.

12.4.2 Unformed Concrete Surfaces. Apply one of the procedures in 12.4.4, Preservation of Moisture immediately after completion of placement and finishing of concrete surfaces not in contact with forms.

12.4.3 Formed Concrete Surfaces. Keep absorbent wood forms wet until they are removed. After form removal, cure the concrete by one of the methods in 12.4.4, Preservation of Moisture.

12.4.4 After placing and finishing, use one or more of the following methods to preserve moisture in concrete:

12.4.4.1 Ponding or continuous fogging or sprinkling.

12.4.4.2 Application of mats or fabric kept continuously wet.

12.4.4.3 Continuous application of steam (under 150°F).

12.4.4.4 Application of sheet materials conforming to ASTM C171.

12.4.4.5 Application of a curing compound conforming to ASTM C309 or Federal Specification TT-C-800. Apply the compound in accordance with the manufacturer's recommendation immediately after any water sheen which may develop after finishing has disappeared from the concrete surface. Do not use the curing compound on any surface against which additional concrete or other material will be bonded unless the curing compound will not prevent bond or unless measures are to be taken to completely remove the curing compound from areas to receive bonded applications.

12.4.4.6 Request application of other accepted moisture-retaining methods.

12.5 Temperature, Wind and Humidity

12.5.1 When high ambient temperatures necessitate protection of concrete immediately after placing or finishing, make provisions in advance of concrete placement for windbreaks, shading, fogging, sprinkling, ponding, or wet covering with a light colored material.

12.5.2 Cold Weather - When the mean daily temperature of the atmosphere is less than 40°F, the temperature of the concrete shall be maintained between 50 and 70°F for the required curing period. Follow recommendations given in "Cold Weather Concreting" (ACI 306R).

12.5.2.1 When necessary, arrangements for heating, covering, insulating, or housing the concrete work shall be made in advance of placement and shall be adequate to maintain the required temperature and moisture conditions as noted in 8.6.3 without injury due to concentration of heat. Salt, chemicals or other foreign materials shall not be mixed with the concrete for the purpose of preventing freezing.

12.5.2.2 Maintaining the Temperature of Concrete After Placing - Methods and Duration.

(a) When lowest expected outside air temperature is above 35°F.

Subject to the approval of the Supervising Engineer for Concrete Construction or his authorized representative, no temporary heat or cover is needed as long as the concrete temperature does not fall below 50°F.

(b) When the lowest expected outside air temperatures are from 35°F to 28°F.

Subject to the approval of the Supervising Engineer for Concrete Construction or his authorized representative, no temporary heat shall be required if the lowest expected temperature of the concrete does not fall below 50°F, but adequate cover must be provided.

The cover may consist of adequate thickness of canvas, plastics, fabric or kraft paper, together with a layer of salt hay at least 4 in. thick, or an approved type of insulating blanket. Special attention should be given to edges and corners. Wood wall forms of sheeting or plywood shall be similarly insulated. Due consideration must be given to thin wall sections and wind exposures which may require additional protection.

These covers shall remain in place after concreting has been completed for 72 hours for regular cement concrete and for 36 hours for mixes using accelerators, high early strength cement or additional cement (at least 15 percent), all subject to the approval of the Supervising Engineer for Concrete Construction or his authorized representative.

(c) When lowest expected outside air temperatures are from 28°F to 18°F.

Subject to approval of the Supervising Engineer for Concrete Construction for all mixes it shall be mandatory to provide both enclosures and temporary heat.

For all mixes made with regular Portland Cement the temporary heat shall be continuously furnished for 72 hours after the completion of placing, in sufficient quantity to maintain a temperature in the concrete of not less than 50°F.

For mixes made with accelerators, high early strength cement or additional cement (at least 15 percent), the temporary heat must be furnished for at least 36 hours after placing is completed.

(d) When lowest expected outside air temperatures are below 18°F. Subject to approval of the Supervising Engineer for Concrete Construction, until such time as Contractor's equipment for adequate heating and control has been approved, no concrete shall be placed without the written approval of the Supervising Engineer for Concrete Construction.

When placing slabs on grade or floor arches, in addition to the precautions in Paragraph 12.5.2.2 (c) above, it is recommended that the tarpaulins, plastics, kraft paper, etc. used for housing and supported on horses, or other framework, shall follow closely the placing of the concrete, so that only a few feet of the finished slab is exposed to the outside atmosphere at any time.

For floor arches such tarpaulins, etc. shall be arranged so that heated air from the story below can circulate freely in the space between the tarpaulin and the freshly placed concrete.

Temporary openings may be left in the floor or the forms to facilitate this. Top covers may be removed between the hours of 8 a.m. and 5 p.m. on days when the temperature is above 35°F. to permit the erection of forms, but they shall be replaced not later than 5 p.m.

12.5.2.3 Methods of Temporary Heating

(a) Within the enclosure such means of temporary heat shall be provided as will maintain the temperature specified. In order of preference, temporary heat may be the use of (a) Heated pipes, coils or radiators (b) combustion heaters vented to the outside (c) blower type heaters.

(b) No method of heating will be permitted which will subject finished floors to excessive concentrations of heat causing rapid drying or to direct contact with combustion gases.

(c) All exposed surfaces within the heated area should be wet down and maintained in a moist condition for curing and fire prevention.

(d) The Contractor shall provide adequate fire protection accessible at all times on each floor and shall maintain watchmen or other attendants to keep the heating units in continuous operation.

12.5.2.4 Insulated Forms

Insulated forms may be used for the protection of concrete, subject to the approval of the Supervising Engineer for Concrete Construction, and on demonstrated degree of protection which will be provided thereby.

12.5.2.5 Preparation of Forms

All forms or surfaces to receive concrete shall be heated above the freezing point and be completely free of frost, snow and ice.

12.5.2.6 Curing

Concrete must be protected from water loss. This shall be accomplished by the application as soon as possible without harm to the concrete surface of: (a) exhaust steam, (b) vapor resistant paper or polyethylene film, (c) curing compounds. In all other respects, curing shall conform to Chapter 12.

12.5.2.7 Removal of Forms

Due to slower strength gain during cold weather, form removal is critical. Regardless of the minimum stripping times listed below, shores shall not be removed before the concrete is strong enough to withstand its own weight and any superimposed load. Reshores must be installed when additional loads, such as form supports for upper floors, must be supported.

(a) When mix is made with ASTM C150, Type I or II Portland Cement: Floor slab forms shall not be stripped in less than 5 days from the time placement was completed. This may be reduced to 3 days when adequately demonstrated by the Contractor to the Supervising Engineer for Concrete Construction or his authorized representative that the safety of the structure is assured without overstress.

(b) When mix is made with accelerators, high early strength cement (ASTM C150, Type III) or additional cement (not less than 15 percent): Floor slab forms shall not be stripped in less than 48 hours after placement was completed. This may be reduced to 40 hours when adequately demonstrated by the Contractor to the Supervising Engineer for Concrete Construction or his authorized representative, that the safety of the structure is assured without overstress.

Wall, column and beam side forms shall not be removed less than 18 hours after placing.

12.5.2.8 Temperature Records

It is required that a temperature record be kept. Such record must show the date, hour, temperatures at several points within the enclosure (Section 12.5.2.2) to show the most favorable and unfavorable conditions to which the concrete is subjected. Thermometer readings shall be taken at the start of the work and at least every four hours thereafter so long as temporary heat is maintained. After the temporary heat is discontinued, the outside air temperature shall continue to be measured and recorded. In the case where no temporary heat is applied, the temperature of the concrete itself shall be recorded during the periods herein before specified in Section 12.5.2.2. Suitable inserts or wells for thermometers shall be provided. This procedure shall be followed for all types of concrete.

12.5.3 Hot Weather

12.5.3.1 During the period June 1, to October 1, arrangements for installation of windbreaks, shading, fog spraying, sprinkling, ponding, or wet covering of a light color shall be made in advance of placement, and such protective measures shall be taken as quickly as concrete hardening and finishing operations will allow. Follow recommendations given in "Hot Weather Concreting" (ACI 605R).

12.5.3.2 Initial Curing

Continuous water curing should be maintained, starting immediately after finishing for a minimum period of twenty-four (24) hours (formed or unformed concrete).

12.5.3.3 Final Curing

After twenty-four (24) hours, curing may be by one of the following methods:

(a) Continuous water curing as above.

(b) Application of an approved plastic membrane.

(c) Spraying with an approved curing compound (preferably white pigmented).

12.5.3.4 In all other respects, curing shall conform to Chapter 12. Upon termination of specified moist curing every effort should be made to reduce the rate of drying by avoiding air circulation.

12.6 Rate of Temperature Change

12.6.1 Excessive temperature changes - Changes in temperature of the concrete shall be as uniform as possible and shall not exceed 5°F in any 1 hr or 50°F in any 24 hr period.

12.6.2 Temperature differentials combined with wind and humidity - At all times of the year when the velocity of air passing over the surface of the freshly placed concrete is greater than 10 miles per hour, and/or the relative humidity in the immediate vicinity of the concrete is less than 50 percent, and/or the concrete temperature is 25 degrees or more above that of the air adjacent to the surface of the concrete, one or more of the protective measures mentioned in Section 12.5.3.1 above shall be taken to prevent an excessive rapid loss by evaporation, from the surface of the freshly placed concrete, of the moisture resulting from normal bleeding.

12.7 Protection from Mechanical Injury

12.7.1 Floors - Floors which have received their final finish shall be closed to all traffic for at least 48 hours following the completion of troweling. Thereafter before the floor is subjected to any traffic it shall be covered with the paper covering for floor protection described in 12.7.4. This protection shall be maintained as long as necessary to avoid damage to the floor.

12.7.2 During the curing period, and thereafter as conditions may require, the concrete shall be protected from damaging mechanical disturbances, particularly excessive load stresses, heavy shock, and excess vibration. All finished concrete surfaces shall be protected from damage caused by construction equipment, materials, or methods, and by rain or running water. Self-supporting structures shall not be loaded in such a way as to overstress the concrete.

12.7.3 Cleaning - When the protective paper covering is removed from floors, the surface shall be again protected from painting and other work. Should there remain any stains, efflorescence or incrustations of mortar on floors, these shall be removed.

12.7.4 Paper covering for floor protection shall consist of two sheets of paper cemented together with a full seal of asphalt and reinforced with cords or sisal fibers completely embedded in the asphalt with not less than 12 reinforcements per inch in each direction all in accordance with ASTM C171. The paper shall be of such quality as to avoid staining the concrete. The paper shall be treated to resist shrinkage and scuffing and shall have a tensile strength of 30 lb per inch of width when wet. This paper is also satisfactory for curing as per 12.4.4.

END OF CHAPTER

CHAPTER 13 - ARCHITECTURAL CONCRETE

13.1 General

13.1.1 Concrete designated by the detailed and general specifications or contract drawings as architectural concrete shall conform to the special provisions of this chapter in addition to all applicable provisions of other chapters in these specifications.

13.1.2 The design of mixes, design of forms, placing of concrete, production of finishes, and final curing shall be so executed as to produce surfaces as near as perfect as possible for all architectural concrete.

13.1.3 Special processes based on preplacement of aggregates with intrusion grouting or other methods to distribute concrete mortar within the preplaced aggregate, shall be as specified in the project specifications.

13.1.4 Special textures and patterns produced by form liners, sand blasting, bushhammering etc., shall be as specified in the project specifications.

13.1.5 Provide all necessary coordination between this work and work of other trades, and other concrete work on the structure. Integrate this work into the structure. Prevent construction operations from causing damage or defects that will impair the quality of the surface.

13.2 Submittals

13.2.1 When required by the detailed specifications, a Test Bent or Mock-up shall be constructed to serve as a standard for construction, workmanship, and approval of the completed finish. When a Test Bent or Mock-up is not called for in the detailed specifications, samples of the Architectural finish shall be incorporated in part of the work that will be covered later. No additional payment will be made for Test Bent, Mock-up or finished sample, the costs made for the Test Bent, Mock-up or finished sample, the costs thereof being considered as included in the cost of the concrete work.

13.2.1.1 Mock-Ups - If the contract Documents require full scale mock-ups of structural items, submit a request for acceptance of their proposed locations at the project site.

13.2.1.2 Drawings and Data - Submit shop drawings and fabricating drawings of forms for architectural concrete; show jointing of facing panels; locations and details of form ties and recesses; details of joints, anchorages, and other accessories; and any necessary alignment bracing.

13.2.2 Procedure for Producing Exposed Aggregate Finish - Prior to placement of concrete, submit the proposed procedure for distributing the exposed aggregate uniformly to obtain the desired effect.

13.2.3 Special Finishes - Submit for acceptance mock-ups or sample panels of aggregate transfer and other special finishes.

13.2.4 Exposed Aggregate Finishes - Submit for acceptance the proposed method of producing exposed aggregate finishes.

13.2.5 Review of Submittals - Do not construct forms until submittals have been accepted. Do not place concrete until submitted plans for batching, mixing, placing, and curing have been accepted.

13.3 Quality Assurance

13.3.1 Concrete Construction Technical Specialists may be required for all operations so listed in the detailed specifications. Provide a technical specialist trained by the specialty item manufacturer. Have the specialist on the job site during the first three days of construction operations using the specialty item and at other times as required by the Project specifications to provide technical assistance.

13.3.2 A preconstruction conference shall be held for this phase of the work. The organization and procedures to be followed by all individuals involved with this phase of the work shall be discussed.

13.3.3 Samples and Mock-Up - Make full-scale mock-ups of structural items. Use the same equipment, materials and procedures that will be used in the final work. Make mock-ups at acceptable locations on the project site. Use mock-ups as samples of required quality of finished construction.

13.4 Product Delivery, Storage, and Handling

Deliver each size of aggregate to the mixer at uniform moisture content throughout each day's concrete production.

13.5 Project Conditions

Protect all architectural concrete from damage, disfiguration, and discoloration from any cause throughout the length of the work.

13.6 Products

13.6.1 Materials

13.6.1.1 Curing Water and coverings - Use curing water and coverings that will not stain the concrete.

13.6.1.2 Bar Supports and spacers - Use stainless steel, plastic, or plastic coated reinforcement supports and spacers near exposed surfaces, except that plastic coated products shall not be used near surfaces that are to be sandblasted.

13.7 Proportioning

Unless the Contract Documents require a plaster coat finish or final painting of surfaces, maintain designated colors and uniformity of color. For concrete of a desired color, use the same mixture proportions throughout. Changes in the quantity of Portland cement per unit volume of concrete shall be particularly avoided. Use only one type and one brand of cement from one mill, only one source and one maximum size of coarse aggregate, only one source of fine aggregate and only one placing consistency. Use air-entrained concrete with a water-cement ratio not exceeding 0.45 by weight. Total air content shall comply with Table 3.5.1.

13.8 Forms

13.8.1 (a) Design forms to produce the required finish. Limit deflection of facing materials between studs as well as deflection of studs and walers of 0.0025 times the span (L/400).

(b) Where natural plywood form finish, grout cleaned finish, smooth rubbed finish, or other special finish is required, ensure that form faces are smooth (forms are faced with plywood, liner sheets, or prefabricated panels) and forms are true to line and grade. Surfaces produced shall require only minor dressing to arrive at true surfaces. Where an as-cast finish is required, do not use any dressing in the finishing operation.

(c) Where as-cast surfaces, including natural plywood form finish, are specified ensure that the panels against which concrete is cast are orderly in arrangement with joints between panels planned in an acceptable relation to openings, structure corners, and other architectural features.

(d) Where panels for as-cast surfaces are separated by recessed or otherwise emphasized joints, the structural design of the forms shall make provisions for locating form ties. Patches of tie holes shall not fall within the panel areas.

(e) Do not reuse forms if there is any evidence of surface wear and tear or defect which would impair the quality of the surface. Thoroughly clean and properly coat forms before reuse.

13.8.2 In addition to shop drawings normally required for concrete work, fabricating drawings of forms of architectural concrete showing the jointing of facing panels, the location of form ties, and any necessary alignment bracing shall be submitted for approval.

13.8.3 Form ties for architectural concrete should be adjusted in length to permit tightening of forms and be of such type as to leave no metal closer than 1 ½ in. to surface. They should not be fitted with lugs, cones, washers, or other devices which will leave holes through the member larger than 7/8 in. in diameter or depressions larger in diameter than the depth at the exposed surface of the concrete. Twisted wire ties shall not be permitted. Ties should be tight fitting or holes pointed to prevent leakage at the holes in the form. Ties that are to be pulled from the wall must be coated with nonstaining bond breaker or encased in oiled paper sleeves to facilitate removal.

13.8.4 In order that reused forms will not contain patches resulting from alterations, forms for architectural concrete shall be reused only on identical sections. Forms shall be thoroughly cleaned and relubricated before reuse. (Note: Requirements for Form oils for use with architectural concrete are covered in Section 4.5).

13.9 Placing of Concrete

13.9.1 Thoroughly clean and inspect formwork and all batching, mixing, conveying, and placing equipment before use. Do not use this equipment for other concrete construction during the time each day it will be used for architectural concrete.

13.9.2 Where architectural concrete requires smooth rubbed or other similar finish in which surface mortar forms the basis of the finish, the coarse aggregate shall be worked back from the forms, by spading, form vibration or other means, leaving a full surface of mortar but avoiding the production of surface voids.

13.9.3 Do not allow vibrators to contact the formwork for exposed concrete surfaces.

13.9.4 Since patching and/or rubbing of as-cast surfaces will be strictly limited, concrete requiring such surfaces shall be so placed as to prevent the formation of surface voids and honeycomb.

13.9.5 During concrete placement, continuously observe formwork for architectural concrete. If deviations from desired elevation, alignment, plumbness, or camber are observed, or if any weakness develops and the falsework shows any undue settlement or distortion, stop work, remove the affected construction if it is permanently damaged, and strengthen the falsework.

13.9.6 Prevent damage to the concrete from form removal. Do not pry against face of concrete. Use only wooden wedges to separate forms from concrete.

13.10 Special Architectural Finishes

13.10.1 Finishing

Finishes shall comply with one of the following finishes required by the Contract Drawings:

13.10.1.1 Textured Finishes - Use textured forms or textured form liners of plastic, wood, or sheet metal. Secure liner panels in forms by cementing or stapling, not by methods which will permit impressions of nail heads, screws heads, washers, or the like to be imparted to the surface of the concrete. Seal edges of textured panels to each other or to divider strips to prevent bleeding of cement paste. Use a sealant that will not stain the concrete surface.

13.10.1.2 Aggregate Transfer Finishes - Produce aggregate transfer and other special finishes that duplicate mock-ups or sample panels prepared in advance and accepted.

13.10.1.3 Exposed Aggregate Finishes - Expose aggregate by an acceptable method including blasting, bush-hammering, or the use of a surface retarder. Provide a concrete surface that will duplicate a mock-up or a sample panel prepared in advance and accepted.

(a) Scrubbed Finish - Provide a scrubbed finish on partially-hardened concrete. Wet the concrete surface thoroughly and scrub with fiber or wire brushes, using water freely, until the surface mortar is removed and the aggregate is uniformly exposed. Then rinse the surface with clear water. If portions of the surface have become too hard to permit uniform aggregate exposure, use dilute hydrochloric acid (one part commercial muriatic acid diluted with 4 to 10 parts water) to remove the excess surface mortar after the concrete is at least 2 weeks old. Remove the acid from the finished surface with clean water within 15 minutes after application.

To facilitate aggregate exposure, cast the concrete against form faces which have been coated with a chemical retarder used in accordance with the manufacturer's recommendations to keep the mortar adjacent to the form from setting.

(b) Blast Finish - Blast the concrete surface to a degree sufficient to expose aggregates. Blasting concrete surfaces includes sandblasting or water blasting. All surfaces with the same specified blast finish shall be done at approximately the same time after placing of concrete. Use stainless steel or plastic reinforcement supports and spacers near concrete surfaces to be blasted. Protect adjacent materials and inserts during abrasive blasting operations.

Unless otherwise specified in Project Specifications, degree of blasting shall be light and shall expose fine aggregate with occasional exposure of coarse aggregate, to produce a uniform color,

and not exceed a reveal of 1/16 inch.

(c) Tooled Finish - Dress the thoroughly cured concrete surface with electric, air, or hand tools to a uniform texture. Then give the surface a hand tooled, rough or fine pointed, crandalled, or bush-hammered surface texture, as specified by Contract Documents.

(d) If blasted, or tooled finishes are specified, remove surface mortar to the degree specified in the Contract Documents.

13.10.2 Applied Finish - When finishes of stucco, cementitious coatings, or similar troweled materials are required or permitted, prepare the surface of the concrete to ensure permanent adhesion of the finish. If the concrete is less than 24 hours old, roughen it with a heavy wire brush or scoring tool. If the concrete is older, roughen the surface mechanically or by etching with acid.

After roughening, wash the surface free of all dust, acid, chemical retarder, and other foreign material before any final finish is applied.

13.11 Patching

13.11.1 Repair of Tie Holes and Surface Defects

13.11.1.1 Repair Area - Where as-cast finishes are specified the total area requiring repair shall not exceed 2 ft in each 1000 ft of as-cast surface. This is in addition to tie hole patches.

13.11.1.2 Color Match - Patches in as-cast architectural concrete shall closely match the color and texture of surrounding surfaces. Determine by trial the mixture for patching mortar to obtain a good color match with the concrete when both patch and concrete are cured and dry. After initial set, dress surfaces of patches manually to obtain the same texture as surrounding surfaces.

13.11.1.3 Exposed Aggregate - In any finishing process which is intended to expose aggregate on the surface, patched areas shall show aggregate faces. The outer 1 inch of patch shall contain the same aggregates as the surrounding concrete. In the case of aggregate transfer finish, use the same selected color aggregates in the patching mixture. After patches have been allowed to cure thoroughly, expose the aggregates together with the aggregates of adjoining surfaces by the same process of mortar removal.

13.11.1.4 Curing of Patches - Cure patches in architectural concrete surfaces for 7 days. Protect patches from premature drying to the same extent as the body of the concrete.

END OF CHAPTER

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CHAPTER 14 - MASS CONCRETE

14.1 General

14.1.1 Concrete sections 4 ft or more in the least dimension are termed mass concrete and shall conform to the special provisions of this chapter in addition to all applicable provisions of other chapters in these specifications.

14.1.2 Additional requirements for heating, cooling, curing and protecting concrete sections more than 6 ft in the least dimension shall be as specified in the project specifications. Consideration shall be given to temperature rise caused by the hydration of the cement. Large differences in temperature within the concrete shall be avoided.

14.1.3 General Requirements - Mass concrete, either plain or reinforced, shall comply with all requirements of Chapters 1 through 12 unless otherwise specified in this Chapter.

14.2 Submittals

Admixtures - If use of retarding or accelerating admixture in mass concrete is needed, submit for acceptance the data on the proposed admixture.

14.3 Materials

14.3.1 Portland cement (Type III), calcium chloride and accelerating type admixtures shall not be used. Type II Portland cement shall be used unless otherwise specified in the Detailed Specifications.

14.3.2 Selection of concrete aggregates for mass concrete is of paramount importance to the quality of the concrete and to the economy and durability of the structure. Aggregates shall conform to the requirements of ASTM C88 and C227.

14.3.3 Admixtures

(a) Do not use calcium chloride or other accelerating admixtures unless specifically permitted by the Engineer.

(b) Use an acceptable retarding admixture, pretested with job materials under job conditions, whenever prevailing temperature conditions make it necessary to offset the effects of high concrete temperature, to permit revibration of the concrete, or to reduce the maximum temperature and rate of temperature rise.

14.4 Proportioning

14.4.1 Cement Content - Conform to requirements of Chapter 3.

14.4.2 The selection of the mix design should recognize that serious volume change stresses can be avoided by controlling the temperature drop of the concrete from the maximum to ambient. Avoidance of thermal shock is important in preventing surface cracks due to temperature gradients. The maximum internal temperature will depend upon:

(1) The initial concrete temperature.

(2) The type of cement used.
(3) The number of bags of cement per cubic yard.

14.4.3 Mixes shall be designed using types and amounts of cement which will reflect lower internal temperatures. Optimum cement is only obtainable by aggregate proportioning that reduces the volume of the void spaces and depends upon aggregate gradation. Minimum cement factors with maximum size aggregate, air entrainment and low water cement ratios should be used, to produce workable concrete and the specified strength.

14.5 Placing

14.5.1 The maximum slump of the concrete shall be 3 in. (with a tolerance of plus 1 in.). The slump of the concrete as placed shall not exceed the maximum slump for which the concrete mixture was proportioned. Concrete with lower than usual slump may be used, provided it can be properly placed and consolidated.

14.5.2 Placing Temperatures - Unless otherwise permitted or specified, the temperature of the concrete when deposited at the point of placement shall not exceed 70°F, nor be less than 35°F. When the temperature of the surrounding air is expected to be below 40°F during placing, or within 24 hours thereafter, the temperature of the concrete when deposited at the point of placement shall be in accordance with ACI 306.1.

14.5.3 Consolidation - Place concrete in layers approximately 18 in. thick. Extend vibrator heads into the previously placed layer of plastic concrete.

14.6 Curing and Protection

The following requirements apply in addition to those of Chapter 12 (Curing and Protection).

14.6.1 The minimum curing period shall be 2 weeks.

14.6.2 Protect the concrete from freezing and moisture loss for the required curing period in accordance with ACI 306.1. Do not use steam or other curing methods that will add heat to the concrete.

14.6.2.1 When the surrounding air temperature falls below 32°F, the surface of the concrete shall be protected. Steam or other curing methods that will add heat to the concrete shall not be used.

14.6.3 The forms shall be kept cool and exposed concrete shall be kept continuously wet for at least the first 48 hours after placing and whenever the surrounding air temperature is above 80°F during the final curing period.

14.6.4 Large differentials of temperature between the interior of the concrete and the exterior of the concrete shall be avoided during the curing period. The rate of cooling shall be regulated to control the temperature gradient drop to about 1° per day.

14.6.5 Rate of Temperature Change - During and at the conclusion of the specified curing period, ensure that the surface temperature of the concrete falls gradually, at a rate that does not exceed 25°F. in any 24 hour period.

END OF CHAPTER

CHAPTER 15 - PRESTRESSED CONCRETE

15.1 General

15.1.1 Job-cast, post-tensioned, prestressed, structural members shall conform to the special provisions of this chapter in addition to all applicable provisions of other chapters in these specifications.

15.1.2 The manufacture, quality, and dimensional tolerances of all prestressed concrete shall be in general accordance with the requirements of the Manual for Quality Control for Plants and Production of Precast Concrete Products published by the Prestressed Concrete Institute.

15.1.3 Definitions

Anchorage - A device used to anchor the tendon to the concrete member.

Bonded tendon - A prestressing tendon which is bonded to the concrete either directly or through grouting.

Coating - Material applied to unbonded tendons to protect them from corrosion; or material applied to either bonded or unbonded tendons to lubricate them during stressing.

Coupling - Any device designed to transfer the prestressing steel wires, bars or strands that comprise a tendon.

Element diameter - The diameter of the individual prestressing steel wires, bars, or strands that comprise a tendon.

Prestressing steel - That element of a post-tensioning tendon which is elongated and anchored to provide the necessary permanent prestressing force.

Sheathing - An enclosure in which post-tensioned tendons are encased to prevent bonding during concrete placement, such as a paper plastic jacket for unbonded tendons, or metal conduit for bonded tendons.

Tendon - An assemblage of steel elements such as wire, bar, or strand, complete with anchorages or anchorage devices used to impart prestress to concrete when the assembly is tensioned.

Unbonded tendon - A tendon which is not bonded to the concrete.

15.2 Submittals

15.2.1 Drawings - Submit shop drawings of prestressed concrete and provide the following information in addition to that required by Sections 4 - Formwork, and 5 - Reinforcement:

15.2.1.1 The location of tendons and sheathing throughout their length.

15.2.1.2 Size, details, location, materials, and stress grade (where applicable) for all tendons and accessories.

15.2.1.3 Jack clearances, jacking procedures, stressing sequence, initial tensioning forces, gauge pressures, and tendon elongation.

15.2.1.4 When design is not detailed on Contract Drawings, drawings shall be stamped by a Licensed New York State Professional Engineer.

15.2.2 Preliminary Data - Submit the following information:

15.2.2.1 Typical stress-strain curve of the prestressing steel.

15.2.2.2 Test results of ultimate strength, yield strength, elongation, and composition for all material not produced in accordance with an ASTM specification.

15.2.2.3 Structural design calculations by a New York State Professional Engineer.

15.2.2.4 Values of the wobble coefficient and the curvature coefficient, and anchorage seating device set data.

15.2.2.5 Test data substantiating the expected coefficients and anchorage slip.

15.2.3 Field Data - Submit prior to installation the following information on actual materials to be used:

15.2.3.1 Stress-strain curve for a sample representing the production lot from which the prestressing tendons will be taken.

15.2.3.2 Notarized mill test reports for the tendons.

15.2.3.3 Results of all tests required in 15.3.1 - Testing, including compliance with 15.5.6 through 15.5.8 for anchorage and couplings.

15.3 Quality Assurance

15.3.1 Testing - Test materials in accordance with the following requirements. Include in the report a detailed description of test procedures and apparatus, as well as test results.

15.3.1.1 Test Assembly - Test, in accordance with 15.3.1.2 and 15.3.1.3 on a third sample for tendons that are not bonded, two samples of each tendon size at least 10 ft in length and complete with standard production quality anchorages.

15.3.1.2 Static Test - Test prestressing steel sample in accordance with the appropriate ASTM Specification of 15.5.1a. Test the tendon assembly with a method that will allow accurate determination of the yield strength, ultimate strength, and elongation of the specimen to ensure compliance with 15.5.1.6 - Anchorage for Bonded Tendons, or 15.5.1.7 - Anchorages for Unbonded Tendons, and 15.5.1.8 - Couplings.

15.3.1.3 Dynamic Test - For unbonded tendons, perform a dynamic test on a representative tendon assembly which shall withstand without failure 500,000 cycles from 60 to 66 and back to 60 percent of its guaranteed minimum ultimate strength. A prototype tendon assembly may be used provided the assembly has not less than 10 percent of the full size tendon strength. Single element tendons using one strand, bar, or wire shall be tested as a complete tendon assembly. Systems utilizing multiple strands, wires, or bars may be tested using a prototype tendon with sufficient number of elements to duplicate the behavior of a full-sized tendon.

15.3.1.4 Grout Testing - Test grout for strength and shrinkage in accordance with CRD C621.

15.3.2 Tolerances - Comply with the following tolerances:

15.3.2.1 The bearing surface between anchorage and concrete shall be concentric with the tendons and perpendicular to the intended direction of the tendon within ± one degree.

15.3.2.2 Tendons, sheathing, and anchorages shall be placed within the tolerances of ACI 117 for reinforcement placement, distance between reinforcement, and concrete cover as noted on the Contract Drawings. These tolerances apply separately to both vertical and horizontal dimensions and may be different for each direction except that in slabs the horizontal tolerance shall not exceed 1 in. in 15 ft of tendon length.

15.4 Product Delivery, Handling, and Storage

Deliver, handle, and store materials in a manner that prevents mechanical damage and corrosion. Store cement and premixed grout to prevent bag set.

15.5 Products

15.5.1 Materials

Use materials which comply with the following requirements:

(a) Prestressing steel shall be of the type and strength required by the Contract Documents and shall conform to one of the following standard specifications:

ASTM A416
ASTM A421
ASTM A722

(b) Strands, wire, and bars not specifically listed in ASTM A416, ASTM A421, or ASTM A722 are permitted to be used provided they conform to the minimum requirements of this Specification and do not have properties that make them less satisfactory than those listed in ASTM A416, ASTM A421, or ASTM A722.

(c) Tendons shall be clean and free of excessive rust, scale, and pitting. A light oxide coating is permissible.

15.5.2 Coatings for Unbonded Tendons - Grease, wax, plastic, or bituminous material may be used as coating material for unbonded tendons. Throughout the range of temperatures anticipated for the structure, the coating material shall remain ductile and free from cracks and shall not become fluid. The coating shall be chemically non-reactive with the tendon, concrete, and the material used for sheathing. The coating shall adhere to and be continuous over the entire tendon length to be unbonded.

15.5.3 Sheathing for Bonded Tendons

(a) Sheathing and duct-forming materials shall not react with alkalies in the cement, shall be strong enough to retain their shape and resist damage during construction, and shall prevent the intrusion of cement paste from the concrete. Sheathing and duct-forming material left in place

shall not cause electrolytic action or deterioration.

(b) The inside diameter of the sheathing or duct shall be at least 1/4 in. larger than the wire, bar, or strand tendon and shall have an inside cross-sectional area at least twice that of the net area of the tendon.

(c) Sheathing shall have grout holes or vents at each end and at all high points except where curvature is small and the sheathing as determined by the Engineer is relatively level. Provide drain holes at all low points if the tendon may be subjected to freezing after placing and before grouting.

15.5.4 Sheathing for Unbonded Tendons - Sheathing for unbonded tendons shall have sufficient tensile strength and water resistance to prevent damage or deterioration during transportation, storage at jobsite, and installation. The sheathing shall be continuous over the unbonded length of the tendons. The sheathing shall prevent the intrusion of cement paste and the escape of coating material. The sheathing may be a continuous tube or spiral wrapping.

15.5.5 Sleeves and Gaskets - Connect sheathing at joints with leaktight sleeves or gaskets.

15.5.6 Anchorage for Bonded Tendons - Bonded tendon anchorages tested in an unbonded state shall develop 90 percent of the minimum specified ultimate strength of the prestressing steel, without exceeding anticipated set at time of anchorage, and without slip. Anchors which develop less than 100 percent of the minimum specified ultimate strength shall be applied only where the bond length is equal to or greater than, the bond length required to develop 100 percent of the minimum specified ultimate strength of the tendon. Provide the required bond length between the anchorage and the zone where the full prestressing force will be developed under service and ultimate loads. Determine the bond length by testing a full-sized tendon. If in the unbonded state the anchorage develops 100 percent of the minimum specified ultimate strength it need not be tested in the bonded state.

15.5.7 Anchorage for Unbonded Tendons - Unbonded tendon anchorages when permitted by the Engineer shall develop the minimum specified ultimate strength of the prestressing steel with an amount of permanent deformation which will not decrease the expected ultimate strength of the assembly. The total elongation under ultimate load of the tendon shall be not less than 2 percent when measured over a minimum gage length of 10 ft.

15.5.8 Couplings - Couplings shall be used only at locations indicated on the Contract Drawings. All couplings shall develop the minimum specified ultimate strength of the prestressing steel without exceeding anticipated set of either the coupling or the prestressing steel, and shall not reduce the ductility of the tendon below the minimum 2 percent strain specified in 15.5.7. Enclose couplings in housings which permit necessary movements during stressing. For bonded tendons, provide fittings to allow complete grouting of all the coupling components.

15.6 Grout

15.6.1 Grout shall consist of a mixture of cement and water unless the gross inside cross-sectional area of the sheath exceeds four times the tendon cross-sectional area, in which case fine aggregate may be added. Use fine aggregate conforming to ASTM C404, Size No. 2, except that all material shall pass the No. 16 sieve.

15.6.2 Fly ash and pozzolanic material admixtures may be added at a rate not to exceed 30 lb per 94 lb of cement. The admixture shall conform to ASTM C618.

15.6.3 An approved shrinkage compensating admixture shall be added to produce a maximum of 10 percent expansion by volume of the grout when measured unconfined.

15.6.4 Admixtures containing chlorides, fluorides or nitrates shall not be used. Other admixtures may be used provided approved tests or performance records show conclusively that they will have no harmful effects on the tendons, accessories or grout.

15.6.5 Proportion grout to achieve a minimum compressive strength of 2500 psi at 7 days when tested in accordance with CRD C621, and have a consistency that will facilitate placement and meet the requirements of 15.8.3.2 - Grout.

The water content shall be the minimum necessary for proper placement, and the water-cement ratio shall not exceed 0.45 by weight or the requirements of Chapter 3.

15.6.6 Mix grout in a high-speed mechanical mixer and pass the grout through a strainer into pumping equipment which has provision for recirculation. Begin pumping grout as soon after mixing as possible. Pumping may be continued as long as the grout retains the proper consistency. Discard grout which has partially set.

15.7 Formwork

15.7.1 Ensure that formwork does not restrain elastic shortening, deflection, or camber resulting from application of the prestressing force, and is sufficiently rigid to prevent displacement of the tendons beyond the tolerances of 15.3.2.

15.7.2 Do not remove form supports until sufficient prestressing force has been applied to support the dead load, formwork, and anticipated construction loads. When a structure will be prestressed in two directions, formwork shall support the load which is redistributed by the partially completed stressing operation.

15.8 Placement and Protection of Tendons and Accessories

15.8.1 Inspection - Conduct a visual inspection to ensure that materials meet requirements of the Specification. The inspection shall include, but not be limited to, the following:

(1) Cleanliness of material and forms
(2) Location of materials and forms
(3) Proper tensioning of prestressing materials

15.8.2 Preparation

15.8.2.1 Grouting - Provide a dependable high-pressure water supply of sufficient volume before beginning grouting. Free sheathing of dirt and other foreign substances by thorough flushing with water immediately prior to grouting.

15.8.2.2 Tendons and Concrete

(a) Keep tendons dry and keep water out of the conduit until flushing tendons prior to grouting. Maintain concrete around grouted tendons at a temperature of 40°F or higher from the time of grouting to at least 3 days after grouting.

(b) Keep sheathing for use with bonded tendons free of grease, oil, paint, and other foreign matter. A light coat of rust is permissible, provided loose rust has been removed and the surface of the steel is not pitted.

(c) Keep tendons for use in unbonded construction clean and undamaged, and protect them with a permanent coating specified in 15.5.2 - Coatings for Unbonded Tendons.

(d) Cover the tendon with an additional field-applied coating of acceptable material.

(e) Keep end anchorages which will be permanently protected with concrete free of loose rust, grease, oil, and other foreign matter except paint.

(f) Protect grout fittings and sheathing for bonded tendons from collapse and other damage. Prior to placing concrete, examine the sheathing and grout fittings for holes, and repair any holes located. If the tendon remains ungrouted for more than 28 days from the time of tendon placement, provide temporary corrosion protection.

15.8.3 Placement

15.8.3.1 Tendons and Accessories - Place tendons and anchorages to meet tolerances of 15.3.2 - Tolerances. Firmly support tendons, sheathing, and anchorages to prevent displacement during concrete placement.

15.8.3.2 Grout

(a) For bonded-tendon construction, inject grout into all voids between prestressing tendons, sheathing, and anchorage fittings. Continue flow until grout of the same consistency as the grout injected flows without the presence of air bubbles from vent openings. Close vent openings progressively in the direction of the flow. After all vent openings have been closed, raise the grouting pressure to at least 50 psi and plug the injection hole.

(b) In the event of a blockage or an interruption of grouting, remove all grout from the tendon sheath by flushing with water.

15.8.4 Tensioning and Other Operations Involving Tendons

15.8.4.1 Sequence - Stress tendons in the sequence, at the concrete strength, and at the construction stage indicated on the Contract Drawings.

15.8.4.2 Tensioning Multiple-Element Tendons - Tension simultaneously tendons composed of multiple strands, wires, or bars in a common sheath unless the effects of interferences between the elements are considered.

15.8.4.3 Prestressing Force - Determine the prestressing force by measuring tendon elongation and checking jack pressure with a calibrated gauge or dynamometer. Calibrate the gauge or dynamometer within six months prior to use; correct any discrepancy which exceeds 5 percent. Base elongation requirements on load-elongation curves for the steel used. For each tendon keep and submit a record of the measured elongations and the gauge pressure or dynamometer readings.

15.8.4.4 Prestress Loss - The total loss of prestress force in any tendon due to unreplaced broken elements shall not exceed 2 percent of the total prestress force.

15.8.4.5 Prevention of Damage to Tendons - Tendons shall not be subjected to excessive temperatures, welding sparks, or electric ground currents. Do not conduct burning and welding operations in the vicinity of tendons without prior acceptance, except as permitted by 15.8.4.6 - Trimming of Tendons.

15.8.4.6 Trimming of Tendons - Superfluous extension of tendons beyond anchorages may be removed by rapid oxyacetylene burning, unless these procedures are contrary to the recommendations of the manufacturer of the prestressing steel.

END OF CHAPTER

NO TEXT ON THIS PAGE

CHAPTER 16 - TESTING

16.1 General

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

16.1.2 Testing Agencies

16.1.2.1 Routine testing of materials, of proposed mix designs, and of resulting concrete for compliance with technical requirements of the specifications shall be the duty of the testing agency or agencies designated in the "Detailed Specifications". The testing agency shall be responsible to and report directly to the Supervising Engineer for Concrete Construction.

16.1.2.2 Testing of field cured test cylinders or testing required because changes in materials or proportions of the mix requested by the contractor, as well as any extra testing of concrete or materials occasioned by the failure to meet specification requirements, shall be at the contractor's expense. All testing of materials proposed, mix designs etc. prior to approval shall be at the contractors expense.

16.1.2.3 Testing agencies that perform testing services on concrete materials shall meet the requirements of ASTM C1077. Testing agencies that perform testing services on reinforcing steel shall meet the requirements of ASTM E329 and the requirements of Chapter 1. The testing agency performing the testing shall be acceptable to the Owner prior to performing any work. Tests of concrete required by this Chapter shall be made by an ACI Concrete Field Testing Technician Grade 1 or equivalent. Equivalent certification programs shall include requirements for written and performance examinations as stipulated in ACI publication CP1.

16.2 Submittals

Testing agencies shall report the results of all tests and inspections performed during the course of the work to the Supervising Engineer for Concrete Construction. Strength tests reports shall be reported on a form satisfactory to the Department. All reports from the Testing Agency, date etc. shall be on forms acceptable to the supervising Engineer for controlled inspection.

16.3 Testing Service

16.3.1 The designated testing agency shall

16.3.1.1 Test the contractor's proposed materials for compliance with the specifications. All such testing shall be at contractors expense.

16.3.1.2 Review and check, if necessary, the contractor's proposed mix design and the strength test data of concrete previously batched and delivered from the particular plant the contractor proposes to use for this job. All such review and checking shall be at the contractors expense.

16.3.1.3 Secure production samples of materials at plants or stockpiles during the course of the work and test for compliance with the specifications unless otherwise noted in the Schedule of Mixes of the "Detailed Specifications."

16.3.1.4 Every time concrete is being placed, a concrete technician shall be employed and stationed at each location on the job site where, and for as long as, concrete is being mixed and discharged from the mixer.

16.3.1.5 Conduct strength tests of the concrete in accordance with the following procedures:

(a) Secure composite samples in accordance with "Method of Sampling Fresh Concrete" (ASTM C172). Each strength test shall be obtained from a different batch of concrete on a representative, truly random basis, avoiding any selection of the test batch other than by a number selected at random before commencement of concrete placement. ASTM C172 is reproduced (in part) herein.

Standard Method of Sampling Freshly Mixed Concrete (ASTM C172-82)

1. Scope

1.1 This method covers procedures for obtaining representative samples of fresh concrete as delivered to the project site on which tests are to be performed to determine compliance with quality requirements of the specifications under which the concrete is furnished (Note 1).

Note 1 - Composite samples are required by this method, unless specifically excepted by procedures governing the tests to be performed such as tests to determine uniformity of consistency and mixer efficiency. Procedures used to select the specific test batches are not described in this method, but it is recommended that random sampling be used to determine overall specification compliance.

3. Sampling

3.1 The elapsed time between obtaining the first and final portions of the composite sample shall be as short as possible, but in no instance shall it exceed 15 min.

3.1.1 Transport the individual samples to the place where fresh concrete tests are to be performed or where test specimens are to be molded. They shall be combined and remixed with a shovel the minimum amount necessary to ensure uniformity and compliance with the minimum time limits specified in 3.1.2.

3.1.2 Start tests for slump or air content, or both, within 5 min after obtaining the final portion of the composite sample. Complete these tests as expeditiously as possible. Start molding specimens for strength tests within 15 min after fabricating the composite sample. Keep the elapsed time between obtaining and using the sample as short as possible and protect the sample from the sun, wind, and other sources of rapid evaporation, and from contamination.

4. Procedure

4.1 Size of sample - make the samples to be used for strength tests a minimum of 1 cu ft (28 L). Smaller samples may be permitted for routine air content and slump tests and the size shall be dictated by the maximum aggregate size.

4.2 The procedures used in sampling shall include the use of every precaution that will assist in obtaining samples that are truly representative of the nature and condition of concrete sampled as follows:

Note 2 - Sampling should normally be performed as the concrete is delivered from the truck mixer to the conveying vehicle used to transport the concrete to the forms; however specifications may require other points of sampling, such as the discharge of a concrete pump.

4.2.1 Sampling from Stationary Mixers, except Paving Mixers - Sample the concrete at two or more regularly spaced intervals during discharge of the middle portion of the batch. Take the samples, so obtained, within the time limit specified in Section 3, and composite them onto one sample for test purposes. Do not obtain samples from the very first or last portions of the batch discharge. Perform sampling by passing a receptacle completely through the discharge stream or by completely diverting the discharge into a sample container. If discharge of the concrete is too rapid to divert the complete discharge stream, discharge the concrete onto a container or transportation unit sufficiently large to accommodate the entire batch and then accomplish the sampling in the same manner as given above. Take care not to restrict the flow of concrete from the mixer, container, or transportation unit so as to cause segregation. These requirements apply to both tilting and nontilting mixers.

(b) In addition, concrete test cylinders shall be made from concrete taken out of the bucket, hopper or forms as directed by the Supervising Engineer for Concrete Construction. The test cylinders shall be separate and distinct from those made from the mixer and shall be made from the same batch as the sample taken from the mixer. Where concrete is placed directly from the mixer into forms, without any intermediate conveyance, these additional cylinders will not be required.

(c) When pumping or pneumatic equipment is used, samples shall be taken at the discharge end.

(d) For all concrete, air-entrained or non-air-entrained, check the slump, air content, concrete temperature, unit weight and yield from the sample of concrete to be used in molding the test specimens.

(e) Compressive strength tests shall be conducted on a set of four specimens molded from each sample in accordance with "Method of Making and Curing Concrete Compression and Flexure Specimens in the Field" (ASTM C 31), and cured under standard moisture and temperature conditions in accordance with Sections 7(a) and 7(b) of ASTM C31.

(f) Test one specimen at 7 days in accordance with ASTM C 39. Test one specimen at 3 days instead of 7 days when high early strength is required.

(g) Test three specimens at 28 days in accordance with "Method of Test for Compressive Strength of Molded Concrete Cylinders" (ASTM C 39). The 28-day test result shall be the average of the strengths of the three specimens, except that if one specimen in a test manifests evidence of improper sampling, molding or testing, it shall be discarded and the remaining two strengths averaged. Should more than one specimen in a test show any of the above defects, the entire test shall be discarded. When high early strength is required, the specimens shall be tested at 7 days instead of 28 days. Whenever the 7-day test results (3-day for high-early strength) are

below 65% of the specified strength and/or whenever the 28-day test results (7-day for high-early strength) are below the specified strength, the specimens shall be stored and kept intact for 30 days or until inspected by both the Supervising Engineer for Concrete Construction or his authorized representative and the contractor, whichever is sooner.

(h) For buildings, make one strength test for each 50 cu. yd. or fraction thereof for each mix design placed in any one day except that a minimum of two tests will be made for each days pour.

(I) The minimum number of tests shown in the following table will be made for concrete used for all structures other than buildings. The Supervising Engineer for Concrete Construction may require that additional tests be made.

Total Cubic Yards of Concrete Placed During Day	Minimum Number of Strength Tests
Up to 100	One for each 50 Cu. Yds.
Over 100 Cu. Yds.	One for each 100 Cu. Yds.

16.3.1.6 Determine air content of normal weight concrete in accordance with either ASTM C231 (Pressure Method) or ASTM C173 (Volumetric Method) when the test specimens are made. The chase indicator is not the approved ASTM volumetric test method. Additional checks for air content shall be made on a regular and frequent basis either by the method outlined in this paragraph or in Paragraph 16.3.1.7 below.

16.3.1.7 Determine air content and unit weight of concrete on a regular and frequent basis in accordance with "Method of Test for Air Content of Freshly Mixed Concrete by the Volumetric Method" (ASTM C 173) for air content, and "Method of Test for Weight Per Cubic Foot, Yield, and Air Content (Gravimetric) for Concrete" (ASTM C 138) for unit weight when the test specimens are made. Additional checks for air content shall be made on a regular and frequent basis either by the method outlined in this paragraph or in Paragraph 16.3.1.8 below. Determine air content of normal weight concrete for each strength test or as directed by the Supervising Engineer for Concrete Construction. Additional tests shall be performed as necessary for control as directed by the Supervising Engineer for Concrete Construction.

16.3.1.8 A Chase indicator, calibrated at least once daily against the readings for air content obtained by methods outlined in 16.3.1.6 and 16.3.1.7 above may be used for additional checking on a regular and frequent basis between tests during the placement of the concrete. Use of the Chase Indicator alone will not be considered as having met the requirements of 16.3.1.6 and 16.3.1.7 for checking air content.

16.3.1.9 Air content shall be as given in Table 3.5.1.

16.3.1.10 Perform all other field testing of concrete as required by the New York City Building Code. Unit Weight tests shall be made with a calibrated one-half (½) cubic foot bucket in accordance with ASTM C138. The unit weight test shall be made concurrently with the preparation of the companion test cylinders. On obtaining the unit weight, the yield shall be immediately computed as the ratio; weight of all the ingredients batched including the water added per cubic yard (from the batching ticket) divided by the unit weight determined times 27. Overyielding or underyielding by more than 2% are cause for concern and should be immediately investigated. Yield should be reported on an appropriate form for each test.

16.3.1.11 Properly note and record the time of day when all checks for slump, air content and yield were made and the corresponding results; from what truckloads the samples were taken, and the identification of the test specimens by class of concrete, clearly indicating exactly where the concrete represented by the sample was deposited in the structure. The Testing Agency shall make available all the test results to the Ready-Mix Concrete producers and the Contractor on the same day that tests are made. Written confirmation of the compression test shall be sent to the Supervising Engineer for Concrete Construction, the Ready-Mix concrete producer and the Contractor within a reasonable time.

16.3.1.12 Establish and control the mix proportioning during the entire progress of the work in accordance with Section 3.9.

16.3.1.13 The testing laboratory shall provide all materials and equipment necessary to perform the required tests including but not limited to cylinder molds, slump cones, a platform scale, calibrated ½ cubic foot bucket, thermometers, pressure air meter for normal concrete and rollameter for lightweight concrete, etc.

16.3.1.14 The Testing Laboratory will be responsible for the safe and undamaged delivery of the test cylinders from the job site to the laboratory. See 16.8.2.8.

16.4 Additional Services

The testing agency shall provide additional services to the extent deemed necessary by the Supervising Engineer for Concrete Construction and shall also perform the following additional services:

16.4.1 Inspect concrete batching, mixing, and delivery operations in accordance with controlled inspection requirements of the administrative building code of the City of New York.

16.4.2 Check batching and mixing operations.

16.4.3 Review the manufacturer's report of each shipment of cement, aggregates, and reinforcing steel and/or conduct laboratory spot checks of these materials as received.

16.4.4 Inspect the location and dimension of the forms, the placing of the reinforcing steel and the placing, conveying and depositing of the concrete.

16.4.5 Sample concrete at point of placement and other locations directed by the Supervising Engineer for Concrete Construction and perform required tests.

16.5 Other Testing Services as Needed

The testing agency shall perform the following testing services when necessary:

16.5.1 Additional testing and inspection required because of changes in materials or mixtures proportion requested by the Contractor.

16.5.2 Additional testing of materials or concrete occasioned by failure to meet specification requirements.

16.6 Payment for Testing Services

Except as noted in 16.1.2.2, 16.3.1.1 and 16.3.1.2 payment for services rendered by the Testing Agency shall be as designated in the Detailed Specifications.

16.7 Authority and Duties of Testing Agency

16.7.1 Technicians representing the testing agency shall inspect the materials and the manufacture of concrete and shall report their findings to the Supervising Engineer for Concrete Construction his or authorized representative, the Contractor, and the ready-mix concrete producer. When it appears that the material furnished or work performed by the contractor fails to fulfill specification requirements, the technician shall direct the attention of the Supervising Engineer for Concrete Construction or his authorized representative, the contractor and the ready-mix concrete producer to such failure.

16.7.2 The technician shall not act as foreman or perform other duties for the contractor. Work will be checked as it progresses, but failure to detect any defective work or materials shall not in any way prevent later rejection when such defect is discovered, nor shall it obligate the Supervising Engineer for Concrete Construction for final acceptance. Technicians are not authorized to revoke, alter, relax, enlarge or release any requirement of the specifications, nor to approve or accept any portion of the work.

16.8 Responsibilities and Duties of Contractor

16.8.1 The use of testing services shall in no way relieve the contractor of his responsibility to furnish materials and construction in full compliance with the plans and specifications. The contractor is required under this contract to provide concrete of the quality specified and it is hereby emphasized that the responsibility for so doing is solely and completely his. It shall be the Contractor's responsibility to work with the Supervising Engineer for Concrete Construction and the Testing Laboratory and to keep himself fully informed of the Evaluation of the Compression Test results as described in Section 17.2.

16.8.2 To facilitate testing services, the contractor shall:

16.8.2.1 Obtain and deliver to the Supervising Engineer for Concrete Construction or his testing agency, without cost, preliminary representative samples of the materials he proposes to use and which are required to be tested.

16.8.2.2 Submit data and test documentation on materials and design mixtures to the Engineer at least 60 days prior to the start of field operations.

16.8.2.3 Submit through the testing agency to the Supervising Engineer for Concrete Construction the procedure, method, and concrete mix design he proposes to use, the name and location of the particular plant he proposes to use, and make written request for approval (see Section 3.9).

16.8.2.4 Submit the quality assurance programs of the testing agency and concrete suppliers and provide copies of all test reports to the Engineer.

16.8.2.5 Furnish such casual labor as is necessary to obtain and handle samples at the project or at other sources of material.

16.8.2.6 Advise the Resident Engineer and the Supervising Engineer for Concrete Construction and the Testing Agency sufficiently in advance of operations to allow for completion of quality tests and for the assignment of personnel.

16.8.2.7 Provide and maintain for the sole use of the testing agency adequate facilities for safe storage and proper curing of concrete test cylinders on the project site for the first 24 hours, as required by ASTM C31. The Contractor shall provide an insulated box of substantial construction, with an insulated hinged cover, large enough to accommodate the maximum number of test cylinders which may be required for any daily placement, for use in storing cylinders on the site until such time as they are transported to the testing laboratory. Heating facilities shall be installed in the box so that the temperature within the box may be maintained at the limits specified by ASTM C31. The box shall be of such dimensions as to permit placing the cylinders in the box one (1) high only. No stacking of cylinders will be permitted. A high-low thermometer shall be placed in the storage box and the maximum and minimum temperatures noted shall be recorded on an appropriate identification card for each test. To minimize the hazard of disturbance during curing, the storage box shall be located in an area free from vibration such as pile driving and traffic of all kinds. No concrete shall be delivered on the site until such storage curing box has been provided. Cylinders shall remain in the curing box until ready for delivery to the testing laboratory but not less than 24 hours.

16.8.2.8 The Contractor shall provide a vehicle for the daily delivery of concrete test cylinders to the applicable testing laboratory. The deliveries shall be made each working day and in no event shall cylinders remain at the site (in the boxes provided for their storage) longer than 48 hours (72 hours over weekends or holidays will be permitted at the Contractor's option and risk.) The testing laboratory will be responsible for the safe and undamaged delivery of such cylinders, in a manner that will prevent the specimens from being jarred, rolled, bounced or dropped en route from site to laboratory.

16.8.2.9 The Contractor shall furnish copies of mill test reports of all shipments of cement, aggregates and reinforcing steel being used to Supervising Engineer for Concrete Construction and the testing agency as required (Chapters 2 and 5).

16.8.2.10 The Contractor shall procure and have available at all times, in his field office at the job site, copies of all test results, reports etc. prepared and submitted by the testing agency as provided under 16.2.

16.9 Tests On Hardened Concrete In Place

16.9.1 General - Tests on hardened concrete shall be performed by the testing agency. The testing shall be at the Contractor's expense when tests are performed to verify the strength of the structure as required by this specification.

16.9.2 Nondestructive Tests - Nondestructive devices in accordance with the appropriate ASTM standards may be permitted by the Engineer/Architect in evaluating concrete strength in place, or for selecting areas to be cored.

16.9.3 Core Tests

16.9.3.1 When required by the Engineer, cores shall be obtained and tested in accordance with ASTM C42. If the concrete in the structure will be dry under service conditions, the cores shall be air dried (temperature 60° to 70°F., relative humidity less than 60 percent) for 7 days before testing and shall be tested dry. If the concrete in the structure will be more than superficially wet under service conditions, the core shall be tested after moisture conditioning in accordance with ASTM C42.

16.9.3.2 At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores as determined by the Engineer shall impair the strength of the structure as little as possible. If, before testing, any cores show evidence of having been damaged subsequent to or during removal from the structure, replacement cores shall be taken.

END OF CHAPTER

CHAPTER 17 - EVALUATION OF CONCRETE QUALITY

17.1 General

Concrete quality shall include but not be limited to satisfactory strength, durability, density (air entrainment), wearing quality, shrinkage cracks, color, physical appearance etc. Wherever there is evidence that any of the concrete in place does not appear to produce the results required by the specifications, such concrete shall be considered questionable and evaluations shall be made in accordance with Sections 17.2, 17.3, 17.4, and 17.5.

17.2 Evaluation of Compressive Test Results

17.2.1 Test results shall be evaluated separately, for each type and each specified strength of concrete. Evaluation shall be in accordance with the Recommended Practice for Evaluation of Compression Test Results of Field Concrete (ACI 214). The strength level of the concrete will be considered satisfactory so long as the averages of all sets of three consecutive compressive strength test results equal or exceed the specified compressive strength f'c and no individual strength test results falls below the specified compressive strength f'c by more than 500 psi.

17.2.2 For evaluation of the control of the quality and uniformity, each type and specified strength of the concrete shall be represented by at least five (5) tests.

17.2.3 The Supervising Engineer for Concrete Construction shall have available at the job site, at all times, the records and results of all tests made of each class of concrete entered on a job record kept for that purpose. The strength tests shall be tabulated, averaged (including moving averages) and plotted on graphs as soon as received, all as described and illustrated in ACI 214. This job record shall be maintained by the Supervising Engineer for Concrete Construction on a continuous basis as the work progresses. Periodic evaluations of the standard deviations, coefficients of variation etc., shall be made.

17.2.4 If results of a number of consecutive seven (7) day tests at any stage of the work indicate abnormalities or results of a number of twenty-eight (28) day tests are below the specified strengths, the production and testing of the concrete shall be immediately investigated and reported upon by the Committee noted in 17.5. It is emphasized that the report of the Committee is advisory. The responsibility for the production of the concrete and the decision as to how to proceed with the work remain with the contractor. However, the decision as to how to proceed is subject to review and approval by the Commissioner.

17.3 Evaluation of Questionable In-Place Concrete Construction by Nondestructive Methods

17.3.1 Visual inspection, impact hammers, sonoscopes, microscopic examination, chemical analysis of the hardened concrete, probes, etc., or other nondestructive testing devices may be used as an indicator of the relative quality and uniformity of various areas of the structure, as an aide in evaluating concrete in place, or in determining locations of areas to be cored. Any program of nondestructive testing shall be performed as directed by and under the supervision of the Committee noted in 17.5. Test results of any program of nondestructive testing and recommendations based thereon shall be reported by the Committee to the Commissioner prior to the commencement of any other program of further testing, if recommended or required. All viewpoints if there is no complete agreement, shall be noted in the report.

17.3.2 Nondestructive Tests

Test results shall be evaluated and shall be valid only if tests have been conducted by properly calibrated equipment in accordance with recognized standard procedures.

17.3.3 Nondestructive Tests

Nondestructive tests shall not be used as the sole basis for accepting or rejecting concrete.

17.4 Evaluation of Questionable In-Place Concrete Construction from Core Tests.

17.4.1 Core test shall be conducted only as recommended and directed by the Committee noted in 17.5 and only after a program of nondestructive testing as noted in 17.3. Core tests shall be evaluated and shall be valid only if tests have been conducted in accordance with specified procedures.

17.4.2 When required, core tests shall be conducted in accordance with "Methods of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete" (ASTM C42). Cores shall be tested saturated-surface-dry or shall be tested air-dry depending as to whether the area where the questionable concrete is located shall be wet or dry under service conditions. Such determination shall be made by the Committee and they shall direct the condition of the cores at the time of testing. If the cores are to be tested dry they shall be air dried (Temp. 60°F., relatively humidity less than 60%) for seven (7) days before the test. The laboratory report shall state whether the cores were tested saturated-surface-dry or surface-dry.

17.4.3 At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Committee so as to least impair the strength of the structure. If, before testing, one or more of the cores shows evidence of having been damaged subsequent to or during removal from the structure, or is obviously defective, it may be replaced.

17.4.4 Concrete in the area represented by a core test, made and tested in accordance with Section 17.4.2 will be considered adequate for structural strength if the average strength of the three cores taken from the immediate area of the questionable concrete is equal to or greater than the specified strength and no single core strength is less than 85 percent of the specified strength (f'c). The Committee shall determine the area where the cores are to be taken and they shall determine the number of cores to demonstrate the adequacy of the questionable concrete. Corrections to the strength values shall be made if the length to the diameter ratio is different from two. No strength correction shall be made for the age of the concrete cores.

If the average strength of the cores as tested is less than the required value, the Committee will make a recommendation as to whether the values obtained are acceptable or they will recommend that the values obtained be checked against a structural analysis as covered in Section 18.5.

17.4.5 Core holes shall be plugged solid as specified in Section 9.3.

17.5 Evaluation Committee

17.5.1 The following shall constitute a Committee for the investigation and the evaluation of the quality of the concrete when there are indications that the requirements of Section 17.1 are not being met. The Resident Engineer (who shall act as Chairman of the Committee), the Supervising Engineer for Concrete Construction or his authorized representative, representatives of the Contractor, the Concrete Producer,

the Testing Agency, the Architect/Engineer responsible for the design and such other members as the Commissioner may designate. Such members of the Committee as designated by the Chairman shall meet whenever request for such meeting is made by any member and/or as otherwise noted in this chapter. Reports and recommendations of the Committee shall be submitted to the contractor and the Commissioner. All viewpoints, if there is no complete agreement shall be noted in the report and reports shall be countersigned by all participating members of the Committee. The Contractor shall be responsible for the preparation and submission of reports.

17.5.2 The functions of the Committee and any reports, recommendations, etc., it submits shall be advisory in nature. The responsibility for the production and quality of the concrete, as previously noted in 16.8.1 remains solely and completely with the Contractor.

17.5.3 All expenses incurred due to the functioning of the Committee shall be borne by the contractor except that all members of the Committee shall serve without fee.

17.6 Additional Curing

If the concrete fails to meet the compressive strength requirements of Chapter 17, additional curing as specified by the Supervising Engineer for Concrete Construction may be required and modifications may be required in the concrete mix design for the remaining concrete work, at the expense of the contractor, in addition to the measures outlined in Section 18.4.

17.7 Acceptance of Concrete

17.7.1 Concrete Strength

Concrete not meeting the requirements of Section 17.2 shall be considered potentially deficient. Steps shall be taken to increase the strength to ensure that the strength level will be satisfactory. For potentially deficient concrete, see Chapter 18.

17.7.2 Air Content

Concrete not within the limits of air entrainment indicated in Table 3.5.1 and tested in accordance with Sections 16.3.1.6 and 16.3.1.7 shall be rejected. Steps must be made to control the proper air content.

17.7.3 Slump

Concrete not within the slump limits of Section 3.6 at the point of placement may be rejected. When the concrete is tested and found to be out of specifications the Contractor shall immediately adjust the mix to bring the mixture within the slump limits of Section 3.6 Concrete Mixes.

END OF CHAPTER

NO TEXT ON THIS PAGE

CHAPTER 18 - ACCEPTANCE OF STRUCTURE

18.1 General

18.1.1 Notwithstanding the provisions of any section of this "General Specification - Concrete," all concrete shall conform to the requirements of the New York City Building Code.

18.1.2 Completed concrete work which meets all applicable requirements will be accepted without qualification.

18.1.3 Completed Concrete work which fails to meet one or more requirements shall be considered potentially deficient. Potentially deficient concrete which has been repaired to bring it into compliance will be accepted without qualification. The decision as to whether it has been brought into compliance except as otherwise noted in this specification shall rest with the Supervising Engineer for Controlled Inspection subject to approval of the Commissioner and the Building Department.

18.1.4 Potentially deficient concrete which cannot be brought into compliance shall be evaluated by the Committee noted in Section 17.5 and a report submitted to the Commissioner. The Commissioner will then, in writing, either accept without qualification or accept subject to Retainage (Section 18.8) or direct that the concrete be reinforced or supplemented with additional construction to bring it into compliance after which it may be resubmitted to the Commissioner.

18.1.5 Repair potentially deficient concrete work by removing and replacing or by reinforcing with additional construction as required by the Engineer. To bring the rejected work into compliance, use repair methods that will maintain the strength of the structure and meet all other applicable requirements for function, durability, dimensional tolerances, and appearance.

18.1.6 Obtain acceptance by the Engineer for repair methods and materials and for modifications needed to assure that concrete work complies with requirements in the Contract Documents.

18.1.7 The Contractor shall pay all costs incurred including redesign and reverification in bringing the concrete work into compliance and acceptance.

18.2 Dimensional Tolerances

18.2.1 Formed surfaces resulting in concrete outlines smaller than required by an amount exceeding the requirements of Section 3.3 of "Recommended Practice for Concrete Formwork" (ACI 347) shall be considered deficient in strength and subject to the provisions of Section 18.4.

18.2.2 Formed surfaces resulting in concrete outlines larger than required, by an amount exceeding the requirements of Section 3.3 of "Recommended Practice for Concrete Formwork" (ACI 347) may be rejected and the excess material shall be subject to removal. If removal of the excess material is permitted, it shall be accomplished in such a manner as to maintain the strength of the section and to meet all other applicable requirements of function and appearance.

18.2.3 Concrete members cast in the wrong location may be rejected if the strength, appearance or function of the structure is adversely affected or misplaced items interfere with other construction.

18.2.4 Inaccurately formed concrete surfaces exceeding the requirements of Section 3.3 of "Recommended Practice for Concrete Formwork" (ACI 347) or Section 13.8.1 and which are exposed to

view may be rejected and shall be repaired or removed and replaced if required.

18.2.5 Finished flatwork exceeding the tolerances of Section 11.9 may be repaired provided that strength or appearance is not adversely affected. High spots may be removed with a terrazzo grinder, low spots filled in with a patch compound or other remedial measures performed as permitted.

18.3 Appearance

18.3.1 Architectural concrete with surface defects exceeding the requirements of Section 13.11.1 and other concrete exposed to view with defects which adversely affect the appearance of the specified finish may be repaired, if possible. If, in the opinion of the Supervising Engineer for Concrete Construction, the defects cannot be repaired, the concrete shall be considered potentially deficient, such concrete shall be evaluated by the Committee noted in Section 17.5 and a report submitted to the Commissioner. The Commissioner will then in writing, either accept without qualification or accept subject to Retainage (Section 18.8) or direct that other remedial measures be taken after which it may be resubmitted to the Commissioner.

18.3.2 Architectural concrete with surface defects exceeding the limitations of 13.11.1 shall be rejected.

18.4 Strength of Structure

18.4.1 The strength of the structure in place will be considered potentially deficient if it fails to comply with any requirements which control the strength of the structure, including but not necessarily limited to the following conditions:

18.4.1.1 Low concrete compression test strength as evaluated by Section 17.2. However, in those areas or members containing such concrete, if a structural analysis by the architect/engineer indicates the completed structure will be suitable for its intended use, i.e., that the stresses which will be developed under design load in the members containing below-strength concrete are less than the design stress permitted for the actual compression test strengths reported and the analysis is approved by the Building Department, the member or members will be accepted without qualification.

18.4.1.2 Low concrete core tests as evaluated by Section 17.4. However, in those areas or members where core tests are made in accordance with Section 17.4, if a structural analysis as specified in 18.4.1.1 indicates the suitability of the structure for its intended use, i.e., that the stresses which will be developed under design load in the members containing below-strength concrete are less than the design stress permitted for the actual core test strengths reported, and the analysis is approved by the Building Department, the areas or members will be accepted without qualification.

18.4.1.3 Reinforcing steel size, quantity, strength, position or arrangement at variance with the requirements of Chapter 5 or the project drawings.

18.4.1.4 Concrete which differs from the required dimensions or location in such a manner as to reduce the strength.

18.4.1.5 Curing less than specified.

18.4.1.6 Inadequate protection of concrete from extremes of temperature during early stages of hardening and strength development.

18.4.1.7 Mechanical injury as defined in Section 12.7, construction fires, accidents or premature removal of formwork likely to result in deficient strength.

18.4.1.8 Poor workmanship likely to result in deficient strength.

18.5 Action Required When Strength Is Potentially Deficient

When the strength of the structure is considered potentially deficient, the following actions may be required by the Engineer/Architect:

(a) Structural analysis or additional testing or both may be required.

(b) Core tests may be required.

(c) If testing is inconclusive or impractical or if structural analysis does not confirm the Safety of the structure, load tests may be required and their results evaluated in accordance with ACI 318.

(d) Concrete work rejected by structural analysis or by results of a load test shall be reinforced with additional construction as required by the Engineer/Architect, or replaced.

(e) Document all repair work performed to bring strength-deficient concrete work into compliance with Contract Documents, and submit the documentation to the Engineer/Architect for acceptance.

18.6 Durability

18.6.1 Criteria for Determining Potential Deficiency

The durability of the concrete work will be considered potentially deficient and therefore the concrete work shall be rejected, if it fails to comply with any of the requirements which control the durability of the structure, including, but not necessarily limited to, the following conditions:

(a) Strength failing to comply with 17.7 - Acceptance of Concrete Strength.

(b) Materials for concrete not conforming with the requirements in Chapter 3.

(c) Concrete not conforming with either the air-entrainment requirements in the Contract Documents or the air content limits of Tables 3.5.1.

(d) Curing not accomplished in accordance with Contract Documents.

(e) Inadequate protection of concrete from extremes of temperature during early stages of hardening and strength development.

18.7 Withholding

18.7.1 Where concrete is placed which is considered to be potentially deficient, whether in strength, appearance, durability or any other quality defined, payment may be withheld at the discretion of the Supervising Engineer for Concrete Construction. If such concrete is subsequently accepted without qualification, then payment shall be made for such concrete including return of all monies withheld.

18.8 Retainage

Potentially deficient concrete which cannot be brought into Compliance and is nevertheless accepted by the Commissioner shall be subject to the following permanent retainage. For every cubic yard of concrete so placed, an amount equal to 10% of the unit price for concrete in place for unit price contracts; or 10% of the price established in the detailed estimate for concrete in place for lump sum contracts; or $10.00 per cubic yard for all concrete so placed, whichever is the greater shall be permanently retained.

18.9 Rejected Concrete

Concrete which has been rejected, in writing, by the Commissioner, shall be removed and replaced. The cost of all such removed and replaced concrete shall be borne by the Contractor.

18.10 Protection of In-Place Concrete

18.10.1 Loading and Support of Concrete

Do not allow construction loads to exceed the superimposed load which the member, with necessary supplemental support, is capable of carrying safely and without damage. Submit for acceptance data on the amount of loading, method of distributing load, and any proposed supplemental support during construction.

18.10.2 Protection from Mechanical Injury

During the curing period, protect the concrete from damaging mechanical disturbances including load stresses, shock, and harmful vibration. Protect all concrete surfaces from damage by construction traffic, equipment, materials, rain or running water, and other adverse weather conditions.

END OF CHAPTER

CHAPTER 19 - SLABS ON EARTH, CURBS AND DRAINAGE STRUCTURES

19.1 General

19.1.1 Base slabs of sewage treatment structures, tanks, and buildings, etc are outside the scope of this chapter.

19.1.2 All concrete under this Chapter shall be normal weight concrete and shall be air-entrained with an air content in accordance with Chapter 3, Table 3.5.1.

19.1.3 Concrete for drainage structures shall be made with Type II Cement.

19.1.4 Coarse aggregate, unless otherwise specified shall conform to Section 2.5.1 except that for concrete base for pavement it shall conform to ASTM C33 Size #3.

19.2 Other City Agencies

Concrete pavement, concrete base for pavement, concrete curbs, headers, sidewalks, inlets, basins, manholes, pipes cradles, and similar type structures which are outside the building line of the site and under jurisdiction of other City agencies, even though constructed as part of this contract, shall be constructed in accordance with the Rules and Regulations, Standard Details and Standard Specifications of the Governing Agency in effect at the time of the award of the contract and as further defined in the Contract plans and detailed Specifications.

Concrete mixes currently specified by other City agencies for similar type work:

(A) DOT - Bureau of Highway Operations (Testing and Evaluation is generally from cores).

Class A 40 (7 bag) Pavements. (1:1-3/4: 2 3/4 mix)
Class B 32 (6 bag) Curbs, sidewalks, headers. (1:2:3-3/4 mix)
Class C 25 (5 bag) Cradles for stone headers. (1:2-1/2:4 mix)
Class D 18 (4 bag) Base for Pavement. (1:3-1/4:5-1/4 mix)

(B) DEP, Bureau of Sewers

Class 40 (7 bag) as Specified. (1:1/2:3 mix)
Class 35 (6 ½ bag) Sewers, manholes, chambers, basins, inlets. (1:1-3/4"3-1/4)
Class 25 (6 bag) Cradles and encasements. (1:2:3-1/2 mix)
Class 15 (4 bag) as Specified. (1:3:5-1/2 mix)

(C) Fire Department

Volumetric Mix - (2:3:5) Encasements. This mix is approximately equal to the Class 40 mix of A or B above. In NYC, this is used for encasement of gasoline tanks and is the responsibility of the plumbing contractor. Work is done in presence of Fire Department inspectors.

19.3 Concrete Strength

19.3.1 Concrete for slabs on earth (sidewalks, pavements, base for pavements, ramps, isolated slabs in buildings, etc), curbs (including headers), drainage structures (inlets, manholes, basins, chambers, pipe

cradles, encasements), and similar type structures which are inside the building line of the site and not under the jurisdiction of other City agencies shall be stone concrete proportioned in accordance with chapter 3, mixed and placed in accordance with Chapters 7 and 8, and cured and protected in accordance with Chapter 12.

Unless otherwise shown or specified, the concrete shall be air-entrained and have the following specified strengths, proportioned as noted (See 3.9.2).

(1) Concrete Pavements, curbs and ramps ..... 4000 psi
(Method I, Fixed Cement Factor)

(2) Concrete headers, sidewalks manholes, basins, chambers, inlets, slabs on earth, isolated slabs in building ..... 4000 psi
(Method I, Fixed Cement Factor)

(3) Concrete cradles encasement ..... 2500 psi
Method I, Fixed Cement Factor)

(4) Concrete base for pavement ..... 2000 psi
(Method III, Average Concrete)

Such concrete shall be tested, evaluated for strength and acceptance in accordance with Chapter 16, 17, and 18.

19.4 Preparation of Foundation

19.4.1 Materials and methods for preparation of earth subgrade, base courses of stone, gravel, cinders, etc for construction of items under this chapter shall conform to the appropriate sections of the Standard Specifications of the New York City Department of Transportation, Bureau of Highway Operations, latest edition. Drainage fill required under concrete slabs on earth within the building shall be as shown or specified. Before proceeding to construct concrete slabs supported on earth, all pipes under these concrete slabs shall receive the required tests. The earth fill shall have been tamped as approved, and any drainage fill required under the slabs on earth, as indicated on the drawings, or specified, shall have been deposited and compacted by rolling or tamping. The subgrade shall have been brought to a true even plane, and compacted to solid bearing with an approved roller (min. 225 pounds per inch of roll) and tamped where required with hand tampers weighing not less than the forty (40) pounds and having a face not exceeding eighty (80) square inches in area. The subgrade shall not be in a muddy or frozen condition, and unsuitable material shall be removed and replace with acceptable material thoroughly compacted. If drainage fill will be installed under concrete slab on earth within the building as shown or specified, it shall be covered with kraft paper or plastic sheets, lapped at least 4 inches at the edge and ends.

19.5 Construction

19.5.1 Concrete slabs on earth shall conform to the requirements of Chapter 11 slabs. Concrete slabs on earth consist of cast-in-place slabs having thickness and reinforcement as indicated on the drawings. Where thickness of slabs are not indicated on the drawings, the minimum thickness shall be four (4) inches except in driveways where it shall be seven (7) inches thick. Ramp slabs shall be crowned as detailed.

19.5.2 Unless otherwise indicated or specified, concrete slabs on earth shall have crack control joints one-quarter inch (1/4") wide and one inch (1") deep at maximum spacing of twenty feet. Such crack control joints shall be filled with an approved joint sealer. If sawed, such joints shall conform to Section 11.7.

19.5.3 Scoring of concrete slabs on earth shall be as indicated, specified or directed and approved by Supervising Engineer for Concrete construction.

19.5.4 Expansion joints shall be provided as indicated on the drawings and at intersections of all exterior paving with vertical wall surfaces, entrance steps and curbs. Expansion joint filler strip material shall extend from the bottom of slabs to within one inch (1") of the top surfaces of such slabs and the remaining one inch (1") cleaned out, and sealed with the poured sealer, finished slightly below the top surface of the slabs and dusted over with Portland Cement while the sealant is still hot. Unless otherwise shown or specified, expansion joints shall be one-half inch (½") wide.

19.5.4.1 Unless otherwise required by the detailed specifications, preformed Expansion Joint Filler shall be as described in Sections 2.15 and 2.16 of the Standard Specifications of the New York City Department of Transportation, Bureau of Highway Operations.

19.5.4.2 Joint Compound: Unless otherwise specified, joint sealing compound for horizontal joints shall be a hot, pure elastic type conforming to ASTM D 1190. Joint compound for vertical joints shall be a cold application type conforming to ASTM D 1850 as described in Sections 2.15 and 2.16 of the Standard Specifications of the NYC Department of Transportation.

19.6 Sidewalk Concrete

19.6.1 This section describes construction of Concrete Sidewalk.

19.6.2 Description

19.6.2.1 Concrete Sidewalk shall be of the width shown or otherwise specified and shall be laid on a foundation six (6) inches thick, unless otherwise specified.

19.6.2.2 Sidewalk shall consist of a single course of concrete four (4) inches thick, except in driveways where it shall be seven (7) inches thick.

19.6.2.3 Concrete shall be pigmented when specified.

19.6.3 Materials

19.6.3.1 Material for foundation shall consist of clean cinders complying with the requirements of Section 2.11, Class 2; NYC Dept. of Transportation Standard Specification or Size No. 3 broken stone or gravel complying with the requirements of Section 2.02, NYC Dept. of Transportation Standard Specification 100 percent of which passes a 2-1/2 in. square sieve; or other approved broken concrete, 100 percent of which passes a 2-1/2 in. square sieve; or other approved granular material containing not more than five (5) percent material passing a No. 200 mesh sieve and not more than five (5) percent retained on a 2 in. square sieve.

19.6.3.2 Concrete shall be proportioned in accordance with Chapter 3 of this specification and shall have a minimum 28 day compressive strength of 3500 psi. Slump values shall be 1 ½ in. minimum to 4 in.

maximum.

19.6.3.3 An approved air-entraining agent shall be added at the time concrete ingredients are mixed with water, to produce an air content (by volume of concrete) of 6-1/2%, with a tolerance of 1-1/2%.

19.6.4 Methods

19.6.4.1 Excavation and Earth Subgrade

Excavation shall be made to dimensions sufficient to permit the setting of forms. The earth subgrade, immediately before foundation material is placed on it, shall be compacted, smooth, parallel to and at the required depth below the finished sidewalk surface and be dampened with water sufficient only to be absorbed by the subgrade. The subgrade shall not be in a muddy or frozen condition and unsuitable material shall be removed and replaced with acceptable material and thoroughly compacted.

19.6.4.2 Foundation

Foundation material shall be placed on the prepared subgrade and thoroughly compacted into a course not less than six (6) inches thick. Unsatisfactory subgrade material shall be removed and replaced with acceptable material and shall be thoroughly compacted to the satisfaction of the Supervising Engineer for Concrete Construction. The top surface shall be parallel to the finished grade and at a distance below the grade equal to the specified thickness of concrete. Additional depth of foundation material for special conditions shall be placed as required by the Supervising Engineer for Concrete Construction. All existing material within the required six (6) inches of foundation shall be removed in its entirety and replaced with material complying with subsection 19.6.4.1 above. The excavated material shall become the property of the contractor and shall be removed from the site to the satisfaction of the Supervising Engineering for Concrete Construction.

19.6.4.3 Forms

Forms shall be made of substantial material (preferably steel) with suitable metal dividing plates and of sufficient strength to satisfactorily resist distortion when fastened together and secured in place. Forms and dividing plates shall be of a depth not less than that of the concrete sidewalk, be properly located with tops set to the designated sidewalk surface and be left in place until the concrete has hardened.

19.6.4.4 Slabs

Concrete sidewalk shall be built in approximately twenty (20) foot slabs between expansion joints, as specified, or if in independent rectangular slabs, they shall be separated by joints approximately one-quarter (1/4) inch wide, and when directed, these joints shall be filled with dry sand. Expansion joints in sidewalk shall coincide with expansion joints in curb. Tooled dummy joints not less than one-half (½) inch in depth shall be provided where directed.

19.6.4.5 Expansion Joints

Transverse expansion joints shall be one-quarter (1/4) inch in width and shall be filled with preformed joint filler to within one (1) inch of the sidewalk surface. The top one (1) inch shall be sealed with asphaltic blown joint filler complying with the requirements of Section 2.16 of the New York City of Department Transportation Standard Specification.

19.6.4.6 Concrete Course

Foundation shall be wetted immediately before concrete is placed. The concrete shall be placed within the forms and thoroughly tamped until the surface is at the finished grade.

19.6.4.7 Pigmenting

When specified in the Detailed Specification, the concrete sidewalk shall be pigmented with a minimum of two (2) pounds of dispersed carbon black per bag of cement to produce a bluestone color. The coloring pigment shall either be treated so as not to cause an increase or decrease of the entrained air content in cement mortar or in the concrete of more than 10% or the amount of air-entrainment agent added to the concrete shall be adjusted to meet the requirements of 19.6.3.3. All cement used for concrete work specified herein shall be of uniform color. Requirements for other colors are covered in the Detailed Specifications.

19.6.4.8 Surface Finish

The top surfaces shall be finished to true smooth planes by screeding, and finally by wooden floats. Each rectangular slab shall have all edges neatly rounded with proper tools and be bounded on all sides by a troweled border about one (1) inch in width.

19.6.4.9 Backfilling

Backfilling shall follow the removal of forms as soon as practicable and unless otherwise permitted, shall be of clean earth, satisfactorily compacted.

19.6.4.10 Protection

Concrete sidewalk shall be carefully protected against injury from rain, frost, the drying effects of the sun and wind, traffic or other causes, by means of suitable guards and covering. Concrete shall be covered with a curing and anti-spalling material such as Durok Shield as manufactured by Durok Building Materials, Inc., Hastings-on-Hudson, N.Y. 11729; Hydrozo concrete Cure and Hydrozo Clear as manufactured by Hydrozo Coatings Co., Lincoln, Nebraska 68051; or an approved equal; and shall contain a fugitive dye and shall be applied in accordance with the instructions of the manufacturer.

19.6.4.11 Concrete curbs, headers, and steel faced concrete curbs, except as otherwise detailed and specified shall be constructed in accordance with the applicable provisions of Section 4.08 and 4.09, Standard Specifications of the New York City Department of Transportation Bureau of Highway Operations except that concrete strength shall be in accordance with Section 19.3 of this specification. Depressed curbs shall be provided where and as indicated on the drawings.

19.6.4.12 Steel Street Curbs shall be standard ship building bulb angles of size indicated on the drawings. The length of straight runs shall be not less than 10'-0" nor more than 20'-0". Curved curb angles shall be bent to the radius indicated, and provided with a straight tangents at the ends 3'-0" in length. Special steel curb angles of type approved shall be provided at drop curbs. Where the length of the special drop curbs exceeds 20'-0" it shall be spliced with an approved type butt welded joint. Anchors shall be welded to all steel curbing. The steel curbs shall be placed within the forms, upon suitable chairs to the proper lines and grades. the joints between units of curbing shall be 1/8 inch. All surfaces of steel curbing, including anchors, shall be thoroughly cleaned of all rust, oil, grease, scale or other foreign matter, before concrete is placed. All surfaces of curbing which is to remain exposed in the finished work shall be shop

primed with one (1) coat of red lead paint complying with the requirements of Fed. Specs. TT-P-86e Class 2 and shall be given two field coats of an approved gray paint.

19.6.4.13 Granite and Bluestone Street Curbs and headers shall be Class A dressed curbs and headers conforming to the requirements of Section 2.12 of the City of New York, Department of Transportation Bureau of Highways Operations Standard Specifications. When specified, a concrete cradle shall be used conforming to the provisions of Section 4.07 Standard Specifications of the Department of Transportation Bureau of Highways except that concrete strength shall be in accordance with Section 19.3 of this Specification.

19.7 Drainage Structures

Unless otherwise shown, detailed or specified, a concrete drainage structures (inlets, basins, manholes, pipe cradles and encasements and similar type structures) shall be built in accordance with the Standard Details and Standard Specifications of the Department of Environmental Protection Bureau of Sewers except that concrete strength shall conform to Section 19.3 of this Specification.

19.8 Special Pavements and/or Sidewalks

Pavements, sidewalk, curbs, etc. which differ from the other provisions of this Chapter in construction, pigmentation or other detail shall be constructed as shown or specified.

END OF CHAPTER

CHAPTER 20 - MEASUREMENT AND PAYMENT

20.1 General

20.1.1 No separate payment will be made for the work of the various chapters of this specification, unless otherwise specified hereinafter or in the Detailed Specifications, and the cost thereof shall be included in the prices bid for the classified or lump sum contract items under this Contract.

20.2 Concrete

20.2.1 Measurement

20.2.1.1 The quantity, in cubic yards, to be measured for payment will be the actual volume of concrete placed in the work in conformity with the Contract Documents.

20.2.1.2 Deductions will be made for the volume of openings, the areas of which are greater than one square foot and for bevels on beams, columns and in wall openings when such bevels exceed four inches on the diagonal faces.

20.2.1.3 Deductions will not be made for portions of piles embedded in concrete foundations.

20.2.1.4 Deductions will not be made for expansion joints, structural steel, steel reinforcement, nor for conduits and pipes with a sectional area less than one square foot.

20.2.2 Payment

20.2.2.1 Concrete used in structures which are to be paid for by lump sum or by the linear foot, or by the square foot, or by the square yard of completed structure, will not be measured for payment under the contract item for concrete unless specifically so stated in the Detailed Specifications.

20.2.2.2 Concrete will be paid for as provided in the Detailed Specifications.

20.2.2.3 When the contract does not provide an item for Portland Cement, the cost thereof shall be included in the prices bid for the contract items under which Portland Cement is required.

20.2.2.4 No payment will be made for concrete or cement placed outside the lines and grades indicated, specified or ordered in writing by the Engineer, or placed to fill unauthorized excavations or used for replacing defective work.

20.3 Reinforcement

20.3.1 Measurement

20.3.1.1 The quantity in pounds, to be measured for payment, shall be the total weight of reinforcing bars and reinforcing mesh incorporated in the work in conformity with the approved working drawings.

20.3.1.2 The total weight of reinforcing bars will be determined by the Engineer using the bar lengths and sizes shown on the approved working drawings, and the unit weight for the bar sizes in accordance with the ASTM specified in the Detailed Specifications.

20.3.1.3 The average unit weights of reinforcing mesh will be determined by the Engineer, using the actual weights of areas of not less than 30 square feet, and such average unit weights will be used in determining the total weight of reinforcing mesh.

20.3.1.4 The weight of wire, clips, ties, spacers or other fastening devices will not be measured for payment.

20.3.2 Payment

20.3.2.1 Steel reinforcement used in structures which are to be paid for by lump sum, or by the linear foot, or by the square foot, or by the square yard of completed structure will not be included in the measurement, unless otherwise specifically stated in the Detailed Specifications.

20.3.2.2 Steel reinforcement will be paid for as provided in the Detailed Specifications.

20.3.2.3 No payment will be made for laps made by the Contractor for his own convenience.

END OF CHAPTER

(NO TEXT ON THIS PAGE)