

## SECTION 3A

### CONCRETE FOR BUILDING CONSTRUCTION

1. APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

#### Federal Specifications (Fed. Spec.):

FF-S-325 & Int. Am-3	Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
SS-S-1401B	Sealing Compound, Hot Applied, for Concrete and Asphalt Pavements
CCC-C-467C	Cloth, Burlap, Jute (or Kenaf)

1.2 U.S. Department of Commerce, National Bureau of Standards (NBS)  
Product Standard:

PS 1-74	Construction and Industrial Plywood
---------	-------------------------------------

#### American Concrete Institute (ACI) Standards:

211.1-81	Selecting Proportions for Normal, Heavyweight, and Mass Concrete
----------	---

301-72 (Rev 1981)	Structural Concrete for Buildings
----------------------	-----------------------------------

318-77 (1980 Suppl)	Building Code Requirements for Reinforced Concrete
------------------------	---

Commentary on Building Code Requirements for Reinforced  
Concrete (ACI-318-77) (First Printing, December 1977 and  
1980 Supplement)

SP-66	ACI Detailing Manual - 1980
-------	-----------------------------

1.4 American Society for Testing and Materials (ASTM) Publications:

A 185-79	Welded Steel Wire Fabric for Concrete Reinforcement
----------	--

A 499-81	Steel Bars and Shapes, Carbon Rolled from "T" Rails
----------	--

A 525-81	Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
----------	---

A 615-82	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
----------	--

A 675-82	Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
C 31-69 (R 1980)	Making and Curing Concrete Test Specimens in the Field
C 33-82	Concrete Aggregates
C 39-81	Compressive Strength of Cylindrical Concrete Specimens
C 42-82	Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
C 78-75 (R 1982)	Flexural Strength of Concrete (Using Simple Beam With Third-Point Loading)
C 94-81	Ready-Mixed Concrete
C 109-80	Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)
C 143-78	Slump of Portland Cement Concrete
C 150-82	Portland Cement
C 171-69 (R 1980)	Sheet Materials for Curing Concrete
C 172-82	Sampling Freshly Mixed Concrete
C 192-81	Making and Curing Concrete Test Specimens in the Laboratory
C 231-82	Air Content of Freshly Mixed Concrete by the Pressure Method
C 260-77	Air-Entraining Admixtures for Concrete
C 309-81	Liquid Membrane-Forming Compounds for Curing Concrete
C 494-82	Chemical Admixtures for Concrete
C 618-80	Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
D 1751-73 (R 1978)	Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
E 96-80	Water Vapor Transmission of Materials

National Ready-Mixed Concrete (NRMCA) Association Publication:

Certification of Ready-Mixed Concrete Production Facilities  
(Jan 1, 1976).

Truck Mixer Manufacturers Bureau (TMMB) Publication:

Truck Mixer and Agitator Standards (Jan 1, 1981; 10th Rev)

2. GENERAL REQUIREMENTS: Full cooperation shall be given other trades to install embedded items. Before placing concrete, embedded items shall have been inspected, and tests for concrete or other materials or for mechanical operations shall have been completed and approved. Suitable templates or instructions shall be used for setting items not placed in the forms.

3. SUBMITTALS:

3.1 Shop Drawings: Shop drawings shall be submitted for approval in accordance with the SPECIAL PROVISIONS. Shop drawings shall show details of reinforcement, setting base plates and bearing plates with expansive grout, sizes and grades of steel, and bending and splicing details.

3.2 Samples: Samples of the following shall be furnished for approval prior to delivery to the jobsite: abrasive aggregates, vapor barriers and joint fillers.

3.3 Certificates of Compliance: Certificates of compliance attesting that abrasive aggregate, floor hardener, perimeter insulation, reinforcement, and premolded joint filler meet the requirements specified shall be furnished in accordance with the SPECIAL PROVISIONS. Certified copies of laboratory test reports, including all test data, shall be submitted for aggregate, admixtures, cement, pozzolan, reinforcement, curing compound, and joint sealer. These tests shall be made by an approved commercial laboratory or by a laboratory maintained by the manufacturers of the material.

3.4 Submitting Mix Proportions: Prior to commencing operations, the Contractor shall furnish a statement giving the maximum nominal coarse aggregate size and the proportions of all ingredients that will be used in the manufacture of each strength of concrete proposed for use. Aggregate weights shall be based on the saturated surface dry condition. The statement shall be accompanied by test results from an independent commercial testing laboratory, attesting that the proportions selected will produce concrete of the qualities indicated. No substitutions shall be made in the materials used in the work without additional tests to show that the quality of the concrete is satisfactory.

4. STORAGE OF MATERIALS: Cement and pozzolan shall be stored in weathertight buildings, bins, or silos which will exclude moisture and contaminants. Aggregate stockpiles shall be arranged and used in a manner to avoid excessive segregation and to prevent contamination with other materials or with other sizes of aggregates. Reinforcing bars and accessories shall be stored above the ground on platforms, skids or other

supports. Other materials shall be stored in such a manner as to avoid contamination and deterioration.

5. MATERIALS: Materials shall conform to the following requirements:

5.1 Admixtures:

5.1.1 Air-entraining admixture shall conform to ASTM C 260.

5.1.2 Water-reducing or retarding admixtures shall conform to ASTM C 494, Type A, B or D.

Aggregates:

5.2.1 Abrasive aggregate shall consist of not less than 55 percent aluminum oxide or silicon-carbide abrasive ceramically bonded together to form a homogenous material sufficiently porous to provide a good bond with portland cement paste or shall be crushed, factory-graded emery aggregate, cubical or polyhedral in form, consisting of not less than 45 percent aluminum oxide and not less than 25 percent ferric oxide. The aggregate shall be well graded from particles retained on the No. 30 sieve to particles passing the No. 8 sieve.

5.2.2 Aggregates for normal weight concrete shall conform to ASTM C 33. Maximum nominal aggregate size shall be 1-1/2 inch unless otherwise specified or required by ACI 318. The aggregate for slabs on grade shall be 3/4-inch in maximum nominal size. Aggregate for blast walls with lacings shall be 1/2-inch in maximum nominal size.

5.3 Anchorage Items: Slots and inserts for anchoring mechanical items to concrete shall be of standard manufacture. Expansion bolts shall conform to Fed. Spec. FF-S-325, Groups II, III, or VIII, and shall be installed in strict accordance with the manufacturer's recommendations. Bolts shall be zinc coated.

5.4 Cementing Materials: Only one source and type of cement shall be used for exposed concrete surfaces of any structure. Pozzolan may be blended with Type I or II portland cement in an amount not exceeding 20 percent of the combined volume. Only one class of pozzolan, from a single source, may be used.

5.4.1 Portland cement shall conform to ASTM C 150, Type I or II.

5.4.2 High-early-strength portland cement shall conform to ASTM C 150, Type III.

5.4.3 Fly ash and pozzolan shall conform to ASTM C 618.

Curing Materials:

5.5.1 Impervious sheet materials shall conform to ASTM C 171, type optional, except that polyethylene film shall be white opaque.

5.5.2 Burlap shall conform to Fed. Spec. CCC-C-467.

5.5.3 Membrane-forming curing compound shall conform to ASTM C 309, Type 1-D, Class A or B.

5.6 Floor Hardener: Floor hardener shall be a colorless aqueous solution containing not less than 2 pounds of zinc and/or magnesium fluosilicate per gallon, or sodium silicate solution having a specific gravity of 16.7 degrees Baume, or an approved proprietary hardener of essentially similar composition.

5.7 Joint Filler Strips:

Contraction joint filler shall consist of hard-pressed fiberboard.

5.7.2 Expansion-joint filler, premolded shall conform to ASTM D 1751, 3/8-inch thick, unless otherwise indicated.

5.8 Joint Sealants: Hot-poured type shall conform to Fed. Spec. SS-S-1401.

5.9 Perimeter Insulation: Perimeter insulation shall be cellular glass, polystyrene, or polyurethane, thickness as indicated.

Reinforcement:

5.10.1 Deformed bars shall conform to ASTM A 615, Grade 60.

5.10.2 Wire mesh shall conform to ASTM A 185.

5.10.3 Dowels for load transfer in floors shall be plain steel bars conforming to ASTM A 675, Grade 80 or ASTM A 499.

5.11 Vapor Barrier: Vapor barrier shall be one of the following:

5.11.1 Asphalt-saturated waterproof reinforced kraft paper.

5.11.2 Polyethylene-coated asphalt-saturated reinforced kraft paper.

5.11.3 Polyethylene sheeting shall be at least 6 mils thick.

5.11.4 Other vapor barrier material shall have a vapor permeance rating not exceeding 0.5 perm as determined by ASTM E 96, Procedure E.

5.12 Water: Water shall be potable, except that non-potable water may be used if it produces mortar cubes having 7- and 28-day strengths at least 90 percent of the strength of similar specimens made with water from a municipal supply. The strength comparison shall be made on mortars, identical except for mixing water, prepared and tested in accordance with ASTM C 109. Water for curing shall not contain any substance injurious to concrete, or which causes staining.

6. CONCRETE STRENGTH AND USAGE:

6.1 Strength Requirements: Compressive strength for concrete shall be as indicated.

6.2 High-Early Strength: Concrete made with high-early strength cement shall have a 7-day strength equal to the specified 28-day strength for concrete made with Type I or II portland cement.

7. PROPORTIONING OF NORMAL WEIGHT CONCRETE MIXES: Mixes shall be proportioned by weight, although water and admixtures may be batched by volume if desired. Trial mixes and testing to meet requirements of the strengths of concrete specified shall be the responsibility of the Contractor. The design mix shall contain materials representative of those proposed for use in the work.

7.1 Admixtures: Concrete exposed to freeze-thaw-cycles shall contain from 5 to 7 percent entrained air as determined by ASTM C 231. Air-entrained concrete also may be used in other parts of the work. Water-reducing or retarding admixtures may be used when approved provided the cement content is not reduced.

7.2 Slump: Slump shall be determined in accordance with ASTM C 143, and shall be within the following limits:

<u>Element</u>	<u>Slump, Inches Minimum</u>	<u>Slump, Inches Maximum</u>
Walls (other than blast walls), columns and grade beams, 10-inch maximum thickness	2	4
Floors, exterior slabs and other building construction	1	3
Blast walls	4	6

Where pumping is approved, the maximum slump is increased to 5 inches, except for floors and exterior slabs.

7.3 Mix Design: Trial mixes having proportions, air content and slump suitable for the work shall be based on ACI 211.1, using at least three different water-cement ratios which will produce a range of strength encompassing that required for the work. The mixes shall be designed for maximum permitted air and slump. For each water-cement ratio, at least three test cylinders for each test age shall be made and cured in accordance with ASTM C 192. They shall be tested at 7 and 28 days in accordance with ASTM C 39 or ASTM C 78, as applicable. From these test results, a curve shall be plotted showing the relationship between water-cement ratio and strength. For each strength of concrete, the maximum allowable water-cement ratio shall be that shown by these curves to produce an average compressive or flexural strength 15 percent greater than specified.

#### 8. SAMPLING AND TESTING DURING CONSTRUCTION:

8.1 General: Testing is the responsibility of the Contractor and shall be performed by an approved testing agency at no additional cost to the Government.

8.2 Cement: Cement shall be sampled either at the mill or ready-mixed concrete plant. No cement shall be used until notice has been given by the Contracting Officer that the test results are satisfactory. Cement that has been stored, other than in bins at the mills, for more than 4 months after being tested shall be retested before use. Such cement and any other cement found by test to be unsuitable shall be removed from the mixing site.

8.3 Pozzolan: Pozzolan shall be sampled either at the source or ready-mixed concrete plant. Approval for use will be based on compliance with the 7-day lime-pozzolan strength requirements and other physical, chemical, and uniformity requirements for which tests can be completed by the time the 7-day lime-pozzolan strength test is completed. Approval for use on the above basis will be contingent on continuing compliance with other requirements of the specifications. Pozzolan that is damaged in shipment, handling, or storage shall be promptly removed from the mixing site.

Aggregates: Aggregates shall be tested as prescribed in ASTM C 33.

8.5 Admixtures: Admixtures which have been in storage at the project site for longer than 6 months or which have been subjected to freezing shall not be used until proved by retest to be satisfactory.

8.6 Tests on Fresh Concrete: Tests for slump and air content shall be made on concrete sampled at the form.

#### Concrete Strength Tests:

8.7.1 Frequency of Testing: The Contractor shall provide, for strength tests, concrete specimens. Samples for strength tests of concrete placed each day shall be taken not less than once a day nor less than once for each 250 cubic yards of concrete. When the total quantity of a given strength of concrete is less than 100 cubic yards, the strength tests may be waived by the Contracting Officer if adequate evidence of satisfactory strength is provided.

8.7.2 Testing Procedures: The samples for strength tests shall be taken in accordance with ASTM C 172. Cylinders and beams for acceptance tests shall be molded and cured in accordance with ASTM C 31. Cylinders shall be tested in accordance with ASTM C 39 and beams shall be tested in accordance with ASTM C 78, by an approved testing laboratory at no cost to the Government. Each strength test result shall be the average of two cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved.

8.7.3 Evaluation of Results: Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength and no individual strength test result falls below the required strength by more than 500 psi. For flexural strength concrete, the strength level of the concrete will be considered satisfactory if the averages of all sets of five consecutive strength test results equal or exceed the required flexural strength and not more than 20 percent of the

strength test results fall below the required strength. If any of these requirements are not met, steps shall be taken immediately to raise the strength level.

8.7.4 Strength Tests: Strength tests of field cured specimens shall be made when directed, to check the adequacy of curing and protection of concrete in the structure, following the procedures in Section 7.4 of ASTM C 31.

8.8 Tests of Concrete in the Structure: When the results of the strength tests on control cylinders indicate that the concrete in place does not meet specification requirements, or if tests of field-cured cylinders indicate deficiencies in protection and curing, cores shall be drilled and tested in accordance with ASTM C 42. The cores shall be drilled at locations designated by the Contracting Officer, and shall be tested by and at the expense of the Contractor. If the results of the tests indicate that the concrete in place conforms to the specified strength within the tolerances stated in ACI 318, the cost of the tests will be borne by the Government. If the results indicate that the concrete does not meet the specified strength within the tolerances stated in ACI 318, the cost of the tests will be borne by the Contractor; in this case the Contractor shall correct the deficiency or he may submit a proposal for a load test. If this proposal is approved, the load test shall be conducted by the Contractor at his expense, and the test results will be evaluated by the Contracting Officer in conformance with ACI 318 and Commentary on Building Code Requirements for Reinforced Concrete. If any concrete fails to meet all of the requirements of the load test, the deficiency shall be corrected in a manner satisfactory to the Contracting Officer and at no additional cost to the Government.

9. FORM WORK: Form work shall be designed and constructed so as to insure that the finished concrete members will conform accurately to the indicated dimensions, lines and elevations, and within the tolerances for concrete buildings specified in ACI 301.

9.1 Design: Studs and wales shall be spaced to prevent deflection of form sheeting. Forms shall be sufficiently tight to prevent leakage of grout and cement paste during placing of the concrete. The bottom of forms shall be accurately fitted and securely attached to the preceding lift so as to assure smooth, completed surfaces free from irregularities and offsets. Joints between form work panels shall be arranged vertically and horizontally to match architectural lines, vertical control joints and construction joints. Temporary openings shall be provided in wall and column forms where needed to facilitate cleaning and inspection. Forms shall be readily removable without impact or damage to the concrete.

9.2 Concrete Surfaces Not Exposed to View: Concrete surfaces which will not be exposed to view in the finished work shall be formed with sound, tight lumber or other material producing equivalent finish.

9.3 Concrete Surfaces Exposed: Concrete surfaces to be exposed shall be formed with a material that is not reactive with concrete. Surfaces shall be equivalent in smoothness and appearance to that produced by new plywood panels conforming to PS 1, Exterior Type, Grade B-B, plyform 5/8-inch thick.

Panels shall be 4 by 8 feet except where otherwise approved or required by the location of openings, architectural lines or joints. Cut surfaces shall be treated with form coating. Form materials with defects that would impair the texture and appearance of finish surfaces shall not be used. Form lining, if used, shall be installed over solid backing.

9.4 Form Ties: Form ties shall be factory-fabricated, removable or snap-off metal ties of a design that will not permit form deflection and will not spall concrete upon removal. Solid backing shall be provided for each tie. Ties shall be fitted with devices that will leave holes in the concrete surface not less than 1/4 inch nor more than 1 inch in diameter and not more than 1 inch deep. That portion of the tie remaining permanently in the concrete shall not project beyond the surface of the concrete and shall be at least 1 inch back from any concrete surface that will be exposed or painted. Bolts and rods that are to be completely withdrawn shall be coated with a nonstaining bond breaker.

9.5 Chamfering: External corners that will be exposed shall be chamfered, bevelled, or rounded, by moldings placed in the forms unless the drawings specifically state that chamfering is to be omitted.

9.6 Form Coating: Forms other than retained-in-place metal forms shall be coated with form oil or form-release agent before reinforcement is placed. The coatings shall be a commercial formulation of satisfactory and proven performance that will not bond with, stain or adversely affect concrete surfaces, and will not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compound. Forms for unexposed surfaces may be wet with water in lieu of oiling, immediately before placing concrete, except that in cold weather with probable freezing temperatures oiling shall be mandatory. Surplus oil on form surfaces, reinforcing steel and construction joints shall be removed before placing concrete.

9.7 Removal of Forms: Forms shall be removed in a manner that will prevent injury to the concrete and insure the complete safety of the structure. Where the structure as a whole is adequately supported on shores, the removable soffit forms, and vertical forms may be removed after 24 hours, provided the concrete is sufficiently strong not to be injured thereby. No shoring shall be removed until the structure in combination with the remaining forming and shoring system has sufficient strength to support safely its weight and the loads placed thereon. This strength shall be demonstrated by job-cured test specimens, and by a structural analysis considering the proposed loads in relation to these test strengths and the strength of forming and shoring system. The job-cured specimens shall be provided in numbers as directed and shall be in addition to those required for concrete control. The specimens shall be removed from molds at the age of 24 hours and shall receive, insofar as possible, the same curing and protection as the structures they represent.

10. REINFORCEMENT: Reinforcement shall be fabricated to the shapes and dimensions shown, and shall be placed where indicated. Reinforcing steel shall not be bent or straightened in a manner injurious to steel or to the concrete. Bars with kinks or bends not shown on the drawings shall not be placed. The use of heat to bend or straighten reinforcing steel will be

permitted only if the entire operation is approved. Bars shall be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If bars are moved more than one bar diameter, the resulting arrangement of bars including additional bars necessary to meet structural requirements shall be approved before concrete is placed. In slabs, reinforcing steel shall not be spliced at points of maximum stress unless otherwise indicated. Laps or splices shall conform to ACI 318. Tack welding to, or of, reinforcement is prohibited. Reinforcement shall be free from loose or flaky rust and mill scale, except tight mill scale, or any other coating which might reduce the bond to concrete. After any substantial delay in the work previously placed, reinforcing steel left for future bonding shall be inspected and cleaned.

10.1 Reinforcement Detailing and Placement: Reinforcement detailing and placement shall conform to ACI 318, except where otherwise indicated.

10.1.1 Wire-mesh reinforcement shall be continuous between expansion, construction, and contraction joints in slabs on grade, and between expansion joints in other slabs. Lap splices shall be at least one full mesh plus 2 inches, staggered to avoid continuous laps in either direction, and securely wired or clipped.

10.1.2 Dowels in slabs on grade shall be installed at right angles to construction and expansion joints. They shall be accurately aligned parallel to the finished surface, and shall be rigidly supported during the placing of concrete. One end of dowels shall be oiled or greased.

10.1.3 Tie-bars in slabs on grade shall be placed at right angles to construction joints. The bars shall be parallel to the finished surface, and shall be rigidly supported during concrete placement.

10.2 Supports: Supports shall be provided in conformance with the ACI SP-66 detailing manual, unless otherwise indicated or specified. Wire ties, when used, shall be 16-gage black annealed wire and shall have ends pointing away from the form. Bar supports for formed surfaces exposed to view shall be plastic protected wire, stainless steel or precast concrete. Precast concrete supports shall be wedge-shaped, not larger than 3-1/2 by 3-1/2 inches, of thickness necessary to produce the required concrete cover, and with an embedded hooked tie wire for anchorage. If the formed surface is exposed to view, the concrete shall be the same quality, texture and color as the finish surface. On ground, precast concrete supports shall be used.

11. PERIMETER INSULATION: Perimeter insulation shall be applied with adhesive to the interior surface of foundation walls, extending from the underside of the slab to the depth indicated.

12. JOINTS: Reinforcement or other fixed metal items shall not be continuous through expansion joints, or through construction or contraction joints in slabs on grade. Reinforcement shall be 2 inches clear from each joint.

12.1 Premolded Expansion Joint Filler: Premolded expansion joint filler strips shall be used in slabs and elsewhere as shown. The filler shall

extend the full slab depth, unless otherwise indicated. The edges of the joint shall be neatly finished with an edging tool of 1/8-inch radius, except where a resilient floor surface will be applied. Where the joint is to receive a sealant, the filler strips shall be installed at the proper level below the finished floor with a slightly tapered, dressed-and-oiled wood strip temporarily secured to the top thereof to form a recess 3/4-inch deep to be filled with sealant. The wood strip shall be removed after the concrete has set.

12.2 Construction Joints: Construction joints in concrete other than slabs on grade: The unit of operation shall not exceed 60 feet for grade beams and other foundation work except footings and shall not exceed 60 feet for roof slabs. Concrete shall be placed continuously so that each unit is monolithic in construction. Fresh concrete shall not be placed against adjoining units until they are at least 24 hours old. Joints not indicated shall be in accordance with ACI 318 or as noted below. Concrete for columns or walls shall be in place at least 2 hours, or until the concrete is no longer plastic, before concreting slabs thereon. In walls having door and window openings, lifts shall terminate at the top and bottom of the opening. Other lifts shall terminate at such levels as indicated or as to conform to structural requirements or architectural details. Where horizontal construction joints are required, a strip of 1-inch square-edged lumber, bevelled to facilitate removal and oiled, shall be tacked to the inside of the forms at the construction joint. Concrete shall be placed to a point 1 inch above the underside of the strip. The strip shall be removed 1 hour after the concrete has been placed, any irregularities in the joint line leveled off with a wood float, and all laitance removed. Prior to placing additional concrete, horizontal construction joints shall be prepared as specified in paragraph PREPARATIONS FOR PLACING CONCRETE.

12.3 Crack-Control Joints: Crack-control joints in slabs on grade are specified in paragraph FLOOR SLABS ON GRADE.

13. INSTALLATION OF ANCHORAGE ITEMS: Anchorage items shall be of sufficient number and size, and shall be located to serve the intended purpose. Slots and dowels shall be provided for anchoring ends and tops of masonry partitions abutting concrete.

#### 14. PREPARATIONS FOR PLACING CONCRETE:

14.1 General: Water shall be removed from the excavation before placing concrete. Any flow of water shall be diverted through side drains without washing over freshly deposited concrete. Hardened concrete, debris, and foreign material shall be removed from the interior of forms. Runways shall be provided for wheeled concrete-handling equipment; such equipment shall not be wheeled over reinforcement nor shall runways be supported on reinforcement. Reinforcement and embedded items shall be inspected, and forms shall be retightened and checked, before placing concrete.

14.2 Concrete on Earth and Rock Foundations: Earth and rock foundations shall be prepared as specified in SECTION: EXCAVATION, FILLING, AND BACKFILLING FOR BUILDINGS. Care shall be taken not to disturb the prepared foundation. Surfaces shall be clean and free from frost, ice, mud, and water.

14.2.1 Vapor barrier material shall be laid over dry or pervious surfaces to receive concrete slabs. Concrete footings and exterior slabs may be laid directly on impervious surfaces which are thoroughly moistened but not muddy at the time of concrete placement.

14.2.2 Immediately before concrete is placed, hard rock foundations shall be cleaned by high velocity air-water jets, sandblasting, or other approved method. Soft rock foundations shall be treated as described above for earth foundations. Rocks of other hardness, or of variable hardness, shall be treated as directed.

14.3 Bonding to Hardened Concrete: Horizontal construction joints shall be prepared 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. The surfaces shall be moist but without free water when concrete is placed.

15. BATCHING, MIXING AND TRANSPORTING CONCRETE: Ready-mixed concrete shall be batched, mixed and transported in accordance with ASTM C 94, except as otherwise specified. Truck mixers, agitators, and non-agitating units shall comply with TMMB "Truck Mixer and Agitator Standards". Plant equipment and facilities shall conform to NRMCA "Certification of Ready Mixed Concrete Production Facilities".

15.1 Admixtures: Admixtures shall be batched within an accuracy of 3 percent. Where two or more admixtures are used in the same batch, they shall be batched separately and must be compatible.

15.2 Control of Mixing Water: All materials shall be batched at the plant. However, where approved by the Contracting Officer, water may be added at the jobsite when the slump is less than specified and the water-cement ratio is less than the approved mix design permits. In this case, water may be added to bring the slump within the specified range without exceeding the approved water-cement ratio. The water shall be injected into the mixer under pressure, and the drum or blades turned a minimum of 30 additional revolutions at mixing speed. There shall be no further addition of water to the batch.

15.3 Site-Mixed Concrete: Site-mixed concrete shall comply with ACI 301.

16. CONVEYING CONCRETE: Concrete shall be conveyed from mixer to forms as rapidly as possible and within the time interval specified in paragraph PLACING CONCRETE by methods which will prevent segregation or loss of ingredients.

16.1 Chutes: When concrete can be placed directly from a truck mixer or other transporting equipment, the chutes attached to this equipment may be used. Separate chutes will not be permitted except when specifically approved.

16.2 Buckets: The bucket design shall be such that concrete of the required slump can be readily discharged. Bucket gates shall be essentially grout tight when closed. The bucket shall provide means for

positive regulations of the amount and rate of deposit of concrete in each dumping position.

16.3 Belt Conveyors: Belt conveyors may be used when approved. Conveyors shall be designed and operated to assure a uniform flow of concrete to the final place of deposit without segregation or loss of mortar, and shall be provided with positive means for preventing segregation of the concrete at transfer points and point of placement.

16.4 Pumps: Concrete may be conveyed by positive displacement pumps when approved. The concrete mix shall be designed for pumping. The pump shall be the piston or squeeze pressure type. The pipeline shall be steel pipe or heavy duty flexible hose. The inside diameter of the pipe shall be at least three times the maximum size of the coarse aggregate. The distance to be pumped shall not exceed the limits recommended by the pump manufacturer. The concrete shall be supplied to the pump continuously. When pumping is completed, the concrete remaining in the pipeline shall be ejected without contaminating the concrete in place. After each operation, the equipment shall be thoroughly cleaned, and flushing water shall be wasted outside the forms.

## 17. PLACING CONCRETE:

17.1 General: Concrete shall be handled from mixer to forms in a continuous manner until the approved unit of operation is completed. Placing will not be permitted when the sun, heat, wind, or limitations of facilities furnished by the Contractor prevent proper consolidation, finishing and curing. Concrete shall be deposited as close as possible to its final position in the forms, and there shall be no vertical drop greater than 5 feet except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it will be effectively consolidated in horizontal layers not more than 12 inches thick, except that all slabs shall be placed in a single layer. Concrete to receive other construction shall be screeded to the proper level to avoid excessive shimming or grouting. Conduits and pipes shall not be embedded in concrete except where specifically indicated or approved.

17.2 Consolidation: Immediately after placing, each layer of concrete shall be consolidated by internal vibrators. The vibrators shall at all times be adequate in effectiveness and number to properly consolidate the concrete; a spare vibrator shall be kept at the jobsite during all concrete placing operations. The vibrations shall have a frequency of not less than 8000 vibrations per minute, and the head diameter and amplitude shall be appropriate for the concrete mix being placed. Vibrators shall be inserted vertically at uniform spacing over the area of placement. The distance between insertions shall be approximately 1-1/2 times the radius of action of the vibrator so that the area being vibrated will overlap the adjacent just-vibrated area by a few inches. The vibrator shall penetrate rapidly to the bottom of the layer and at least 6 inches into the preceding layer if there is such. It shall be held stationary until the concrete is consolidated and then withdrawn slowly. The use of form vibrators shall be specifically approved. Vibrators shall not be used to transport concrete within the forms. Slabs 4 inches and less in thickness shall not be

consolidated by internal vibration; properly designed vibrating screeds or other approved technique shall be used.

17.3 Time Interval Between Mixing and Placing: Mixed concrete which is transported in truck mixers or agitators, or concrete which is truck mixed, shall be discharged within 1-1/2 hours after introduction of the cement to the aggregates, except that when the concrete temperature exceeds 85 degrees F. this time shall be reduced to 45 minutes. Concrete shall be placed within 15 minutes after it has been discharged from the truck.

17.4 Cold Weather Requirements: Special protection measures, approved by the Contracting Officer, shall be used if freezing temperatures are anticipated before the expiration of the specified curing period. The ambient temperature of the space adjacent to the concrete placement and surfaces to receive concrete shall be maintained at not less than 40 degrees F. The temperature of the concrete when placed shall be not less than 50 degrees F. nor more than 75 degrees F. Heating of the mixing water or aggregates will be required to regulate the concrete placing temperature. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals or other materials shall not be incorporated in the concrete to prevent freezing.

17.5 Warm Weather Requirements: Concrete placed during warm weather shall have the lowest temperature practicable to produce under the conditions. The temperature of the concrete as placed shall not exceed 85 degrees F. except where an approved retarder is used. The mixing water and/or aggregates shall be cooled, if necessary, to maintain a satisfactory placing temperature. In no case shall the placing temperature exceed 95 degrees F.

#### 18. TREATMENT OF FORMED SURFACES:

18.1 General: Within 24 hours after forms are removed, surface defects shall be remedied as specified herein. For permanently exposed surfaces, fins shall be removed and holes left by removal of tie rods shall be reamed and filled by dry-packing. For all surfaces, honeycomb and other defective areas shall be cut back to sound concrete and to a depth of not less than 1 inch. The edges of the cut shall be perpendicular to the surface of the concrete. The prepared area shall be dampened and brush-coated with neat cement grout. The repair shall then be made using a stiff mortar, preshrunk by allowing the mixed mortar to stand for 45 minutes and then remixed, thoroughly tamped into place; in lieu of hand patching, a small shotcrete gun may be used. Patches shall be finished flush with adjacent surfaces. For surfaces permanently exposed to view, the cement used shall be a blend of job cement with white cement proportioned so that the final color after curing will be the same as the adjacent concrete. The temperature of concrete, mortar patching material and ambient air shall be above 50 degrees F. while making the repair and during the ensuing 72 hours moist curing period. Concrete with excessive honeycomb, or other defects which affect the strength of the member, will be rejected or the defects shall be corrected as directed by the Contracting Officer.

18.2 Smooth Finish: After the above repairs have been completed, smooth finish will be applied to above grade walls. A mortar mix consisting of

one part portland cement and two parts well-graded sand passing a No. 30 sieve, with water added to give the consistency of thick paint, shall be used. Where color is important, white cement shall be used to replace part of the job cement. After the surface has been thoroughly wetted and allowed to approach surface dryness, the mortar shall be vigorously applied to the area by clean burlap pads or by cork or wood-floating, to completely fill all surface voids. Excess grout shall be scraped off with a trowel. As soon as it can be accomplished without pulling the mortar from the voids, the area shall be gone over with burlap pads having on their surface the same sand-cement mix specified above but without any mixing water, until all of the visible grout film is removed. The finish of any area shall be completed in the same day, and the limits of a finished area shall be made at natural breaks in the surface. The surface shall be continuously moist cured for 48 hours. The temperature of the air adjacent to the surface shall be not less than 50 degrees F. for 24 hours prior to, and 48 hours after, the application. In hot, dry weather the smooth finish shall be applied in shaded areas.

#### 19. FLOOR SLABS ON GRADE:

19.1 Capillary Vapor Barrier: Immediately before placing concrete, the capillary water barrier or subgrade under slabs in buildings shall be covered with a vapor barrier. Punctures and tears during subsequent operations shall be patched. Edges shall be lapped not less than 4 inches and ends not less than 6 inches. Patches and lapped joints shall be sealed with a pressure-sensitive adhesive or pressure-sensitive tape, not less than 2 inches wide and compatible with the membrane.

19.2 Placement: Placement of concrete shall be continuous so that each unit of operation will be monolithic. Concrete shall be consolidated, screeded to grade, and prepared for the specified finish. Jointing shall be as shown on the drawings. If not shown, crack control shall be provided by construction joints at the perimeter of individual panels placed in checkerboard fashion, or by longitudinal construction joints and transverse contraction joints if lane placement is used. Lanes shall be one panel wide. Joints not shown shall be located at column centerlines and intermediate intervals so that each panel shall be not more than 600 square feet in area. Panels shall be approximately square with no side longer than 25 feet. Square-shaped isolation joints shall be provided for the full slab depth at columns on separate footings, and shall be constructed so that corners of isolation joints will meet crack-control joints. Where columns bear on thickened slabs or thickened edges, contraction or expansion joints shall be offset from these locations. Forms shall remain in place for at least 24 hours after concrete placement.

19.3 Contraction Joints: Contraction joints may be constructed by inserting hardpressed fiberboard strips into the plastic concrete, or by cutting the concrete with a saw after it has set. Unless otherwise indicated or directed, the joints shall have a width of 1/8 inch and a depth of approximately 1/4 the slab thickness or the maximum size of the coarse aggregate, whichever is greater.

19.3.1 Fiberboard strips shall be of the required dimensions and as long as practicable. After the first floating, the concrete shall be grooved

with a tool at the joint locations. The strip shall be inserted in the groove, using a U-shaped sheet metal device fitted over the top edge of the strip to maintain true alignment while the strip is depressed until the top edge is flush with the surface of the slab. When the concrete has set sufficiently to retain the strip, the device shall be withdrawn. The slab shall be floated and finished as specified. Working of the concrete adjacent to the joint shall be the minimum necessary to fill voids and consolidate the concrete. Where indicated on the plans, the top portion of the filler shall be sawed out after the curing period to form a recess for sealer.

19.3.2 Joint sawing shall be early enough to prevent uncontrolled cracking in the slab, but late enough that this can be accomplished without appreciable spalling. Concrete-sawing machines shall be adequate in number and power, and with sufficient replacement blades to complete the sawing at the required rate. Joints shall be cut to true alignment and shall be cut in sequence of concrete placement. Sludge and cutting debris shall be removed.

19.4 Construction and Expansion Joints: Construction and expansion joints shall be finished with an edging tool having 1/8-inch radius, except where a floor covering will be applied.

19.5 Sealing Construction and Expansion Joints: Sealing contraction and expansion joints in slabs shall be filled with Fed. Spec. SS-S-1401 joint sealant, except where floor covering is required. Joint surfaces shall be clean, dry, and free of oil or other foreign material. Joint sealant shall be applied as recommended by the manufacturer of the sealant. All joints shall be completely filled with sealer, which shall be well bonded to the concrete and free from voids.

20. FINISHING CONCRETE FLOOR AND ROOF SLABS: In cold weather, the air temperature in areas where concrete is being finished shall not be less than 50 degrees F. In hot windy weather, a covering or windbreaks shall be provided as necessary to prevent premature setting and drying of the surface. The dusting of surfaces with dry materials or the addition of water during finishing will not be permitted. Finished surfaces shall be plane, with no deviation greater than 1/8 inch when tested with a 10-foot straightedge. Surfaces shall be pitched to drains.

20.1 Rough Slab Finish: Immediately after consolidation, slabs shall be screeded with straightedges to bring the surface to the required finish level with no coarse aggregate visible. The resulting rough slab finish shall be suitable to receive fill and mortar setting beds.

20.2 Wood-Float Finish: The screeding shall be followed immediately by darbying or bull floating before bleeding water is present, to bring the surface to a true, even plane. After the concrete has stiffened so that it will withstand a man's weight without imprint and the water sheen has disappeared, it shall be wood floated. Roof surfaces shall be finished with a magnesium float in lieu of wood floating, and left free of ridges and other projections.

20.3 Monolithic Steel Trowel Finish: Immediately following the wood floating, the surface shall be steel-trowelled to produce a smooth, dense

surface free from blemishes including trowel marks. In lieu of hand finishing, an approved power finishing machine may be used in accordance with the directions of the machine manufacturer. A final hard steel troweling shall be done by hand.

**Non-Slip Finish:**

20.4.1 Broom finish shall be given to exterior platforms, ramps, loading docks, stair treads, landings and entrances. After wood floating, the surface shall be lightly steel trowelled, and then broomed with a fiber-bristle brush in a direction transverse to that of the main traffic.

20.4.2 Abrasive aggregate finish shall be given to main traffic aisles. After wood floating, the abrasive aggregate shall be uniformly sprinkled over the surface at a rate of not less than 1/4 psf. The surface shall be steel-trowelled to a smooth, even finish of uniform texture. Immediately after curing, the abrasive aggregate shall be exposed by steel brushing, rubbing with an abrasive stone, or sandblasting. Wood float finish is required where conductive flooring occurs.

20.5 Hardener: Hardener shall be applied to all interior concrete floors which do not receive a floor covering. Prior to treatment, the floors shall be thoroughly cured, cleaned and perfectly dry with all work above them completed. Zinc and/or magnesium fluosilicate shall be applied evenly in three coats, with 24 hours between coats. The first coat shall be 1/3 of full strength, the second 1/2 of full strength, and the third coat 2/3 of full strength. Each coat shall be allowed to remain wet on the concrete surface for 15 minutes. Sodium silicate shall be applied evenly in three coats, with 24 hours between coats. The sodium silicate shall be applied full-strength at the rate of 1/3 gallon per 100 square feet. Approved proprietary hardeners shall be applied in conformance with the manufacturer's instructions. After the final coat is dry, any surplus hardener shall be removed from the surface by scrubbing and mopping with water. Membrane-forming curing compound shall not be used on surfaces which are to be treated with floor hardener.

**CURING AND PROTECTION:**

21.1 General: All concrete shall be cured by an approved method for the period of time given below:

Type III cement	3 days
Type I, II, IP or IS cement	7 days
Type I or II cement blended with pozzolan	12 days

Immediately after placement, concrete shall be protected from premature drying extremes in temperatures, rapid temperature change, mechanical injury and injury from rain and flowing water. All materials and equipment needed for adequate curing and protection shall be available and at the placement prior to placing concrete. No fire or excessive heat shall be permitted near or in direct contact with the concrete at any time. Curing shall be accomplished by any of the following methods, or combination thereof, as approved.

21.2 Moist Curing: Concrete to be moist-cured shall be maintained continuously wet for the entire curing period. If water or curing materials stain or discolor concrete surfaces which are to be permanently exposed, the concrete surfaces shall be cleaned. When wooden forms are left in place during curing, they shall be kept wet at all times. If the forms are removed before the end of the curing period, curing shall be carried out as on unformed surfaces, using suitable materials. Horizontal surfaces shall be cured by ponding, by covering with a 2-inch minimum thickness of continuously saturated sand, or by covering with waterproof paper, polyethylene sheet, polyethylene-coated burlap or saturated burlap.

21.3 Membrane Curing: Membrane curing shall not be used on surfaces that are to receive any subsequent treatment depending on adhesion or bonding to the concrete; except a styrene acrylate or chlorinated rubber compound meeting Class B requirements may be used for surfaces which are to be painted or stained. Membrane curing compound shall not be used on surfaces that are maintained at curing temperatures with free steam. The curing compound shall be applied to formed surfaces immediately after the forms are removed and prior to any patching or other surface treatment except the cleaning of loose sand, mortar, and debris from the surface. The surfaces shall be thoroughly moistened with water and the curing compound shall be applied to slab surfaces as soon as the bleeding water has disappeared, with the tops of joints being temporarily sealed to prevent entry of the compound and to prevent moisture loss during the curing period. The compound shall be applied in a one-coat continuous operation by mechanical spraying equipment, at a uniform coverage in accordance with the manufacturer's printed instructions. Concrete surfaces which have been subjected to rainfall within 3 hours after curing compound has been applied shall be resprayed by the method at the coverage herein specified. On surfaces permanently exposed to view, the surface shall be shaded from direct rays of the sun for the duration of the curing period. Surfaces coated with curing compound shall be kept free of foot and vehicular traffic, and from other sources of abrasion and contamination during the curing period.

21.4 Cold Weather: The air and forms in contact with concrete shall be maintained at a temperature above 50 degrees F. for the first 3 days and at a temperature above 32 degrees F. for the remainder of the specified curing period.

## 22. SETTING BASE PLATES AND BEARING PLATES:

22.1 General: After being plumbed and properly positioned, column base plates, bearing plates for beams and similar structural members, shall be set with damp-pack bedding mortar, except where expansive grout is indicated. The thickness of the mortar or grout shall be approximately 1/24 the width of the plate, but not less than 3/4 inch. Plates shall be set and anchored to the proper line and elevation. Metal wedges, shims, or setting nuts shall be used for leveling and plumbing structural members. Concrete and metal surfaces in contact with grout shall be clean and free of oil and grease. Concrete surfaces shall also be free of laitance and shall be dampened.

22.2 Damp-Pack Bedding Mortar: Damp-pack bedding mortar shall consist of 1 part cement and 2-1/2 parts fine aggregate as specified in paragraph

MATERIALS, with the water content such that a mass of mortar tightly squeezed in the hand will retain its shape but will crumble when disturbed. The space between the top of the concrete and bottom of the bearing or base plate shall be packed with the bedding mortar by tamping or ramming with a bar or rod until it is completely filled.

22.3 Expansive Grout: Expansive grout shall be a commercial formulation of proven and satisfactory performance requiring only the addition of water. It shall be the metal-oxidizing or expansive cement type, with a minimum 28-day compressive strength of 5000 psi. Literature and test data on the material shall be furnished confirming that a flowable mixture will give a hardened grout with a slight expansion and possessing the other properties needed for the application proposed. Mixing and placing shall conform with the material manufacturer's written recommendations. Forms of wood or other suitable material shall be used to retain the grout. The grout shall be placed quickly and continuously, completely filling the space without segregation or bleeding of the mix.

22.4 Treatment of Exposed Surfaces: For metal-oxidizing grout, exposed surfaces shall be cut back 1 inch and immediately covered with a parge coat of mortar consisting of 1 part portland cement and 2-1/2 parts fine aggregate by weight, with sufficient water to make a plastic mixture. The parge coat shall have a smooth finish. For other mortars or grouts, exposed surfaces shall be left untreated. Curing shall comply with paragraph CURING AND PROTECTION.