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USACE / NAVFAC / AFCESA / NASA **UFGS-32 13 11 (August 2010)**

Preparing Activity: USACE **Superseding UFGS-32 13 11 (November 2009)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2012
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DIVISION 32 - EXTERIOR IMPROVEMENTS

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CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 32 13 11

CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS
08/10

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NOTE: This guide specification covers the requirements for construction of concrete pavement for Army, Navy and Air Force airfields and heavy-duty roads, parking areas, hardstands, and vehicular pavement greater than 8000 cubic meters (10,000 cubic yards).

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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PART 1 GENERAL

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NOTE: In preparing contract specifications for concrete pavement, the designer will use UFC 3-250-04FA STANDARD PRACTICE FOR CONCRETE PAVEMENTS for guidance. State highway specifications may only be used for non organizational parking, roads, streets, and driveways where the equivalent passes of an 18-kip EASL are less than 5.7 million. All organizational vehicle parking, roads and airfield concrete pavements will use the Unified Facilities guide specifications without exception.

Contact the Corps of Engineers Transportation

Systems Center (TSMCX), the Air Force major command (MAJCOM) pavement engineers, or Naval Facilities Engineering Command (NAVFAC) for guidance on interpreting and editing this specification section.

This specification section is structured for Contractor sampling and testing of materials and mixture proportioning. If Government sampling, testing and mixture proportioning is required, contact the TSMCX, MAJCOM pavement engineers, or NAVFAC for specification language.

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1.1 UNIT PRICES

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NOTE: Any project large enough to use this guide specification should have Unit Price payment. For Lump Sum payment, include concrete unit price from Government estimate in paragraph Payments to provide cost basis for calculating payment reduction.

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1.1.1 Measurements

The quantity of concrete to be paid for will be the volume of concrete in cubic meters yards including thickened edges [monolithic curb], where required, placed in the completed and accepted pavement. Concrete will be measured in place in the completed and accepted pavement only within the neat line dimensions shown in the plan and cross section. No deductions will be made for rounded or beveled edges or the space occupied by pavement reinforcement, dowel bars, tie bars, or electrical conduits, nor for any void, or other structure extending into or through the pavement slab, measuring 0.1 cubic meter 3 cubic feet or less in volume. No other allowance for concrete will be made unless placed in specified locations in accordance with written instructions previously issued by the Contracting Officer. The quantity of other materials specified herein, and used in the construction of the work covered by this section, will not be measured for payment, but will be considered a subsidiary obligation of the Contractor, covered under the price per cubic meter yard for concrete. Joint sealing materials are covered in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS or Section 32 13 73 COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS.

1.1.2 Payments

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NOTE: Use the applicable paragraph from the two choices below and delete the other.

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1.1.2.1 Unit Price

The quantity of concrete measured as specified above will be paid for at the contract unit price when placed in completed and accepted pavements. Payment will be made at the contract price for cubic meter yard for the scheduled item, with necessary adjustments as specified below. Payment will constitute full compensation for furnishing all materials, equipment, plant and tools, and for all labor and other incidentals necessary to

complete the concrete pavement, except for other items specified herein for separate payment.

1.1.2.2 Lump Sum

The quantity of concrete will be paid for and included in the lump-sum contract price. If less than 100 percent payment is due based on the pay factors stipulated below, a unit price of [_____] per cubic meter yard will be used for purposes of calculating the payment reduction.

1.1.3 Payment of Lots

When a lot of material fails to meet the specification requirements, that lot will be accepted at a reduced price or shall be removed and replaced. The lowest computed percent payment determined for any pavement characteristic (i.e., thickness, grade, and surface smoothness) discussed below shall be the actual percent payment for that lot. The actual percent payment will be applied to the unit price and the measured quantity of concrete in the lot to determine actual payment. Use results of strength tests to control concreting operations. Strength will be evaluated, but will not be considered for payment adjustment. Any pavement not meeting the required 'specified strength' shall be removed and replaced at no additional cost to the Government.

1.1.4 Payment Adjustment for Smoothness

a. Straightedge Testing: Location and deviation from straightedge for all measurements shall be recorded. When more than 5.0 and less than or equal to 10.0 percent of all measurements made within a lot exceed the tolerance specified in paragraph "Surface Smoothness", after any reduction of high spots or removal and replacement, the computed percent payment based on surface smoothness will be 95 percent. When more than 10.0 percent and less than or equal to 15.0 percent of all measurements exceed the tolerance, the computed percent payment will be 90 percent. When more than 15.0 and less than or equal to 20.0 percent of all measurements exceed the tolerance, the computed percent payment will be 75 percent. When more than 20.0 percent of the measurements exceed the tolerance, the lot shall be removed and replaced at no additional cost to the Government.

b. Profilograph Testing: Location and data from all profilograph measurements shall be recorded. When the Profile Index of a 0.1 km 0.1 mile segment of a lot exceeds the tolerance specified in paragraph "Surface Smoothness" by 16 mm per km 1.0 inch per mile but less than 32 mm per km 2.0 inches per mile, after any reduction of high spots or removal and replacement, the computed percent payment based on surface smoothness will be 95 percent. When the Profile Index exceeds the tolerance by 32 mm per km 2.0 inches per mile but less than 47 mm per km 3.0 inches per mile, the computed percent payment will be 90 percent. When the Profile Index exceeds the tolerance by 47 mm per km 3.0 inches per mile but less than 63 mm per km 4.0 inches per mile, the computed percent payment will be 75 percent. When the Profile Index exceeds the tolerance by 63 mm per km 4.0 inches per mile or more, the lot shall be removed and replaced at no additional cost to the Government.

1.1.5 Payment Adjustment for Plan Grade

When more than 5.0 and less than or equal to 10.0 percent of all measurements made within a lot are outside the specified tolerance, the

computed percent payment for that lot will be 95 percent. When more than 10.0 percent but less than 50 percent are outside the specified tolerances, the computed percent payment for the lot will be 75 percent. In any areas where the deviation from grade exceeds the specified tolerances by 50 percent or more, the deficient area shall be removed and replaced at no additional cost to the Government.

1.1.6 Payment Adjustment for Thickness

Using the Average Thickness of the lot, determine the computed percent payment for thickness by entering the following table:

Computed Percent Payment for Thickness

Determined by Cores millimeters	Deficiency in Thickness Pavements Equal To Over 200 mm Thick	Deficiency in Thickness Pavements Less than 200 mm Thick
0.00 to 6.2	100	100
6.3 to 12.5	75	65
12.6 to 18.9	50	0
19.0 or greater	0	0

Computed Percent Payment for Thickness

Determined by Cores Inches	Deficiency in Thickness Pavements Equal To Over 8 Inches Thick	Deficiency in Thickness Pavements Less than 8 Inches Thick
0.00 to 0.24	100	100
0.25 to 0.49	75	65
0.50 to 0.74	50	0
0.75 or greater	0	0

Where 0 percent payment is indicated, the entire lot shall be removed and replaced at no additional cost to the Government. Where either of the two cores from a sublot show a thickness deficiency of 19 mm 0.75 inch or greater, [13 mm 0.50 inch for pavements 200 mm 8 inches or less in thickness] two more cores shall be drilled in the sublot and the average thickness of the four cores computed. If this average shows a thickness deficiency of 19 mm 0.75 inch or more [13 mm 0.50 inch for pavements 200 mm 8 inches or less in thickness] the entire sublot shall be removed.

1.2 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2009) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 214R	(2011) Evaluation of Strength Test Results of Concrete
ACI 305R	(2010) Guide to Hot Weather Concreting
ACI 306R	(2010) Guide to Cold Weather Concreting

ASTM INTERNATIONAL (ASTM)

ASTM A184/A184M	(2006e1) Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A185/A185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A497/A497M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
ASTM A615/A615M	(2009b) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2007b) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A996/A996M	(2009b) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM C1017/C1017M	(2007) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete

ASTM C1064/C1064M	(2011) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1077	(2011c) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C117	(2004) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C123/C123M	(2011) Standard Test Method for Lightweight Particles in Aggregate
ASTM C1240	(2011) Standard Specification for Silica Fume Used in Cementitious Mixtures
ASTM C1260	(2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C138/C138M	(2010b) Standard Test Method for Density ("Unit Weight"), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142/C142M	(2010) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143/C143M	(2010a) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2011) Standard Specification for Portland Cement
ASTM C1567	(2011) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2006) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C1646/C1646M	(2008a) Making and Curing Test Specimens for Evaluating Frost Resistance of Coarse Aggregate in Air-Entrained Concrete by Rapid Freezing and Thawing

ASTM C172/C172M	(2010) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C174/C174M	(2006) Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C192/C192M	(2007) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C294	(2005) Standard Descriptive Nomenclature for Constituents of Concrete Aggregates
ASTM C295/C295M	(2011) Petrographic Examination of Aggregates for Concrete
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2010) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2011a) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2011) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C494/C494M	(2011) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2011) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2008a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C666/C666M	(2003; R 2008) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C78/C78M	(2010) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

ASTM C88	(2005) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C881/C881M	(2010) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C94/C94M	(2011b) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2011) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D1751	(2004; R 2008) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2008) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D2419	(2009) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors
ASTM D3665	(2007e1) Random Sampling of Construction Materials
ASTM D4791	(2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D75/D75M	(2009) Standard Practice for Sampling Aggregates

INNOVATIVE PAVEMENT RESEARCH FOUNDATION (IPRF)

IPRF INTERIM TEST PROTOCOL	Test Method to Assess Potential Reactivity of Aggregates in Presence of Airfield Deicing Chemicals (Mortar Bar Test)

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA QC 3	(2003) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)

CTM 526	(2002) Operation of California Profilograph and Evaluation of Profiles

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 130	(2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles
COE CRD-C 143	(1962) Specifications for Meters for Automatic Indication of Moisture in Fine Aggregate
COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 55	(1992) Test Method for Within-Batch Uniformity of Freshly Mixed Concrete
COE CRD-C 662	(2009) Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)

1.3 SYSTEM DESCRIPTION

This section is intended to stand alone for construction of concrete pavement. However, where the construction covered herein interfaces with other sections, the construction at each interface shall conform to the requirements of both this section and the other section, including tolerances for both.

1.3.1 Surface Smoothness

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NOTE: Edit these paragraphs as appropriate to the project. If it is desired to restrict surface smoothness testing and evaluation to either straightedge method or profilograph method, retain the one and delete the other; otherwise, retain both as a Contractor's option. Require use of the profilograph method for airfield taxiways and runways. When the profilograph method is allowed, and there are areas with dimensions less than 60 m (200 feet) in any direction, retain the straightedge method for these short runs.

For Navy projects, delete the profilograph, and use the straight edge for both longitudinal and transverse smoothness measurements.

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Use the profilograph method for all longitudinal testing, except for paving lanes less than 60 m 200 feet in length. Use the straightedge method for transverse testing, for longitudinal testing where the length of each pavement lane is less than 60 m 200 feet, and at the ends of the paving limits for the project. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.), finish the surface to meet

the approval of the Contracting Officer. Detailed notes shall be kept of the results of the testing and a copy furnished to the Government after each day's testing.

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NOTE: Retain first bracketed statements for airfield projects and delete the second set. Retain second bracketed statements for roads and streets projects and delete first set.

****

a. Straightedge Testing: The finished surfaces of the pavements shall have no abrupt change of 6 mm 1/4 inch or more, and all pavements shall be within the limits specified when checked with an approved 4 m 12 foot straightedge. [Runways and taxiways shall have a variation from the specified straight edge not greater than 3 mm 1/8 inch in the longitudinal direction and not greater than 6 mm 1/4 inch in the transverse direction. All other airfield areas shall have a variation from a straight edge not greater than 6 mm 1/4 inch in either the longitudinal or transverse direction.] [Roads, streets, tank hardstands, vehicular parking areas, and open storage areas shall have a variation from the specified straight edge not greater than 6 mm 1/4 inch in either the longitudinal or transverse direction.]

b. Profilograph Testing: The finished surfaces of the pavements shall have no abrupt change of 6 mm 1/4 inch or more, and each 0.1 km 0.1 mile segment of each pavement lot shall have a Profile Index not greater than specified when tested with an approved California-type profilograph. [Runways and taxiways shall have a Profile index not greater than 110 mm per km 7 inches per mile in the longitudinal direction. Runway and taxiway transverse smoothness shall be measured with the straight edge method and the straight edge requirements shall apply. All other airfield areas shall have a Profile Index not greater than 140 mm per km 9 inches per mile in the longitudinal direction.] [Roads, streets, tank hardstands, vehicular parking areas and open storage areas shall have a Profile index not greater than 140 mm per km 9 inches per mile in the longitudinal direction.]

c. Bumps ("Must Grind" Areas): Any bumps ("must grind" areas) shown on the profilograph trace which exceed 10 mm 0.4 inch in height shall be reduced by diamond grinding in accordance with subparagraph "Diamond Grinding of PCC Surfaces" below until they do not exceed 7.5 mm 0.3 inch when retested. Such grinding shall be tapered in all directions to provide smooth transitions to areas not requiring grinding.

d. Testing Method: After the concrete has hardened sufficiently to permit walking thereon, but not later than 48 hours after placement, test the entire surface of the pavement in each lot in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. If any pavement areas are ground, these areas shall be retested immediately after diamond grinding. The entire area of the pavement shall be tested in both a longitudinal and a transverse direction on parallel lines. The transverse lines shall be 4.5 m 15 feet or less apart, as directed. The longitudinal lines shall be at the centerline of each paving lane shown on the drawings, regardless of whether the Contractor is allowed to pave two lanes at a time, and at the 1/8th point in from each side of the lane. Other areas having obvious deviations shall also be tested. Longitudinal testing lines shall be continuous across all joints. Transverse testing lines for pilot lanes

shall be carried to construction joint lines and for fill-in lanes shall be carried 600 mm 24 inches across construction joints, and the readings in this area applied to the fill-in lane. Straightedge testing of the longitudinal edges of slipformed pilot lanes shall also be performed before paving fill-in lanes as specified below.

1). Straightedge Testing: The straightedge shall be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and measuring the maximum gap between the straightedge and the pavement surface. Measurements shall be determined along the entire length of the straight edge.

2). Profilograph Testing: Perform profilograph testing using approved equipment and procedures described in CTM 526. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for each 0.1 km 0.1 mile segment of the pavement lot. Grade breaks on aprons [parking lots] shall be accommodated by breaking the profile segment into short sections and repositioning the blanking band on each section. The "blanking band" shall be 5 mm 0.2 inches wide and the "bump template" shall span 25 mm 1 inch with an offset of 10 mm 0.4 inch. The profilograph testing of the last 9.1 m 30 feet of a paving lane in the longitudinal direction from each day's paving operation shall be counted on the following day's continuation lane. The profile index shall be computed for each pass of the profilograph (3 per lane) in each 0.1 km 0.1 mile segment. The profile index for each segment shall be the average of the profile indices for each pass in each segment. Profilographs of unequal lengths shall be scaled and proportioned to an equivalent 0.1 km 0.1 mile as outlined in the CTM 526. A copy of the reduced tapes shall be furnished the Government at the end of each day's testing.

1.3.2 Edge Slump and Joint Face Deformation

a. Edge Slump: When slip-form paving is used, not more than 15.0 percent of the total free edge of each pavement panel shall have an edge slump exceeding 6 mm 1/4 inch and none of the free edge of the pavement lot shall have an edge slump exceeding 9 mm 3/8 inch. (A pavement panel is defined as a lane width by the length between two adjacent transverse contraction joints. The total free edge of the pavement will be considered to be the cumulative total linear measurement of pavement panel edge originally constructed as non-adjacent to any existing pavement; i.e., 30 m 100 feet of pilot lane originally constructed as a separate lane, will have 60 m 200 feet of free edge; 30 m 100 feet of fill-in lane will have no free edge, etc.,). The area affected by the downward movement of the concrete along the pavement edge shall not exceed 450 mm 18 inches back from the edge.

b. Joint Face Deformation: In addition to the edge slump limits specified above, the vertical joint face shall have a surface within the maximum limits shown below:

Offset from Straightedge Applied Longitudinally To Pavement Surface	Offset from Straightedge Applied Longitudinally To Vertical Face	Offset From Straightedge Applied Top to Bottom Against the Joint Face	Abrupt Offset in Any Direction	Offset of Joint Face From True Vertical
Airfield Pavement				
3 mm (1/8 in)	6 mm (1/4 in)	9 mm (3/8 in)	3 mm (1/8 in)	8 mm/100 mm (1 in/12 in)
All other Pavement				
6 mm (1/4 in)	All other items same as airfield pavement			
	All other items same as airfield pavement			

c. Slump Determination: Immediately after the concrete has hardened sufficiently to permit walking thereon, the pavement surface of each lot shall be tested by the Contractor. Testing shall be performed with a minimum 4 m 12 foot straightedge to reveal irregularities exceeding the edge slump tolerance specified above. The vertical edge slump shall be determined at each free edge of each slipformed paving lane constructed. The straightedge shall be placed transverse to the direction of paving and the end of the straightedge located at the edge of the paving lane. Measurements shall be made at 1.5 to 4.5 m 5 to 15 foot spacings, as directed, commencing at the header where paving was started. Initially measurements shall be made at 1.5 m 5 foot intervals in each lane. When no deficiencies are present, the Contracting Officer may approve an increase in the interval. When any deficiencies exist, the interval will be returned to 1.5 m 5 feet. In no case shall the interval exceed 4.5 m 15 feet. In addition to the transverse edge slump determination above, the Contractor, at the same time, shall check the longitudinal surface smoothness of the joint on a continuous line 25 mm 1 inch back from the joint line using the 4 m 12 foot straightedge advanced one-half its length for each reading. Other tests of the exposed joint face shall be made to ensure that a uniform, true vertical joint face is attained. The measurements shall be made by the Contractor, shall be properly referenced in accordance with paving lane identification and stationing, and a report given to the Contracting Officer within 24 hours after measurement is made. The report shall also identify areas requiring replacement.

d. Excessive Edge Slump: When edge slump exceeding the limits specified above is encountered on either side of the paving lane, additional straightedge measurements shall be made, if required, to define the linear limits of the excessive slump. The concrete slabs having excessive edge slump or joint deformation shall be removed and replaced to the next transverse joint in conformance with paragraph: REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Use of slip-form paving equipment and procedures that fail to consistently provide edges within the specified tolerances on edge slump and joint face deformation shall be discontinued and the pavements shall be constructed by means of standard paving procedures using fixed forms.

1.3.3 Plan Grade

Within 5 days after paving of each lot, the finished surface of the

pavement area shall be tested, by running lines of levels at intervals corresponding with every longitudinal and transverse joint to determine the elevation at each joint intersection. The results of this survey shall be recorded and a copy given to the Government at the completion of the survey of each lot. The finished surfaces of airfield runway, taxiway, and apron pavements shall vary not more than 13 mm 1/2 inch above or below the plan grade line or elevation indicated. The surfaces of other pavements shall vary not more than 19 mm 3/4 inch. The above deviations from the approved grade line and elevation will not be permitted in areas where closer conformance with the planned grade and elevation is required for the proper functioning of appurtenant structures. The finished surfaces of new abutting pavements shall coincide at their juncture.

1.3.4 Flexural Strength

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NOTE: Normally, concrete for airfield pavement should be proportioned and accepted on the basis of 90-day flexural strength. However, if, because of scheduling time limits, it is necessary to proportion on the basis of 28-day flexural strength, modify these subparagraphs as appropriate. If it is desired to use 28-day strength for design of airfield pavement, approval must be obtained through the TSMCX, MAJCOM pavement engineers, or NAVFAC. Make the same changes if this is concrete for road pavement proportioned for 28-day strength (no approval needed).

The designer may choose the first Option "Cylinders/Beam" or the second Option "Beams" for strength testing.

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Submit certified copies of laboratory test reports and sources for cement, supplementary cementitious materials (SCM), aggregates, admixtures, curing compound, epoxy, and proprietary patching materials proposed for use on this project. All aggregate tests shall have been performed no earlier than 6 months prior to contract award. Each lot of pavement will be evaluated for acceptance in accordance with the following procedures.

a. Sampling and Testing: For acceptance, one composite sample of concrete from each sublot shall be obtained in accordance with ASTM C172/C172M from one batch or truckload. Test cylinders 152 x 305 mm 6 x 12 inches shall be fabricated and cured in accordance with ASTM C31/C31M, and tested in accordance with ASTM C39/C39M. Test beams 152 x 152 mm 6 x 6 inches shall be fabricated and cured in accordance with ASTM C31/C31M; and tested in accordance with ASTM C78/C78M. Two test cylinders per sublot (8 per lot) shall be tested at 14 days.

b. Computations: Average the eight 14-day strength tests for the lot. The average strength shall be used in accordance with paragraph "Concrete Strength for Final Acceptance" in PART 2.

1.3.5 Thickness

Each lot of pavement will be evaluated for acceptance and payment adjustment in accordance with the following procedure. Two cores, between 100 and 150 mm 4 and 6 inches in diameter, shall be drilled from the

pavement, per sublot (8 per lot). The Contractor is responsible for drilling the cores within 3 days after lot placement, filling the core holes with an approved non-shrink concrete, respraying the cored areas with curing compound, and for measuring the cores. Each core shall be inspected for voids, thickness of paste on the surface, and depth of reinforcement (if required). Provide the results with the thickness measurement data. Eight measurements of thickness shall be made around the circumference of each core and one in the center, in accordance with ASTM C174/C174M, using calibrated calipers for specimens longer than 250 mm 10 inches. The pavement thickness from the 8 cores for the lot shall be averaged and shall be evaluated as described in paragraph: PAYMENT ADJUSTMENT FOR THICKNESS above.

1.3.6 Diamond Grinding of PCC Surfaces

In areas not meeting the specified limits for surface smoothness and plan grade, high areas shall be reduced to attain the required smoothness and grade, except as depth is limited below. High areas shall be reduced by grinding the hardened concrete with an approved diamond grinding machine after the concrete is 14 days or more old. Grinding shall be accomplished by sawing with an industrial diamond abrasive which is impregnated in the saw blades. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the concrete pavement or joint faces. The saw blades shall be 3 mm 1/8-inch wide and there shall be a minimum of 55 to 60 blades per 300 mm 12 inches of cutting head width depending on the hardness of the aggregate. Each machine shall be capable of cutting a path 3 to 4 ft 0.9 to 1.2 m 3 to 4 ft wide. Grinding equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints will not be permitted. The area corrected by grinding the surface of the hardened concrete shall not exceed 10 percent of the total area of any sublot. The depth of diamond grinding shall not exceed 6 mm 1/4 inch. All pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above, shall be removed and replaced in conformance with paragraph REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS. [In pavement areas given a wire comb or tined texture, areas exceeding 2 square meters 25 square feet that have been corrected by diamond grinding shall be retextured by transverse grooving using an approved grooving machine of standard manufacture. The grooves shall be 6 mm 1/4 inch deep by 6 mm 1/4 inch wide on 37 mm 1-1/2 inch centers and shall be carried into, and tapered to zero depth within the non-corrected surface, or shall match any existing grooves in the adjacent pavement.] All areas in which diamond grinding has been performed will be subject to the thickness tolerances specified in paragraph: Thickness, above.

1.4 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control

System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment
Proposed Techniques[; G][; G, [_____]]

SD-05 Design Data

Proportioning Studies; G, ED

SD-06 Test Reports

Sampling and Testing; G, ED

SD-07 Certificates

Contractor Quality Control Staff; G, ED
Laboratory Accreditation; G, ED
Commercial Laboratory; G, ED

1.5 QUALITY ASSURANCE

****

NOTE: Where they are available, specify only ACI certified personnel. Check the American Concrete Institute (ACI) website for local availability (www.concrete.org/Certification).

****

1.5.1 Contractor Quality Control Staff

Submit American Concrete Institute certification for Contractor Quality Control staff. Qualifications and resumes for petrographer, surveyor, concrete batch plant operator, and profilograph operator. All Contractor Quality Control personnel assigned to concrete construction shall be American Concrete Institute (ACI) certified in the following grade (or shall have written evidence acceptable to the Contracting Officer's representative of having completed similar qualification programs):

a. CQC personnel responsible for inspection of concrete paving operations: ACI Concrete Transportation Inspector.

b. Lead Foreman or Journeyman of the Concrete Placing, Finishing, and Curing Crews: ACI Concrete Flatwork Technician/Finisher.

c. Field Testing Technicians: ACI Concrete Field Testing Technician, Grade I.

d. Laboratory Testing Technicians: ACI Concrete Strength Testing Technician and Laboratory Testing Technician, Grade I or II.

1.5.2 Other Staff

Submit for approval, the qualifications and resumes for the following staff:

a. Petrographer: Bachelor of Science degree in geology or petrography, trained in petrographic examination of concrete aggregate according to ASTM C294 and ASTM C295/C295M and trained in identification of the specific deleterious materials and tests identified in this specification. Resume shall detail the education, training and experience related to the project-specific test methods and deleterious materials and shall be submitted at least 20 days before petrographic and deleterious materials examination is to commence.

b. Licensed Surveyor: All survey work shall be performed under the supervision of a Licensed Surveyor.

c. Concrete Batch Plant Operator: National Ready Mix Concrete Association (NRMCA) Plant Manager certification at the Plant Manager level.

d. Profilograph Operator: Certification by equipment manufacturer or a state Department of Transportation.

1.5.3 Laboratory Accreditation

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NOTE: The USACE validation letter requirement does not apply to the Navy.
****

Laboratory and testing facilities shall be provided by and at the expense of the Contractor. Submit accreditation of the commercial laboratory by an independent evaluation authority, indicating conformance to ASTM C1077, including all applicable test procedures. The laboratories performing the tests shall be accredited in accordance with ASTM C1077, including ASTM C78/C78M and ASTM C1260. The accreditation shall be current and shall include the required and optional test methods, as specified throughout

this Section. Onsite temperature-controlled concrete curing facilities shall be provided.

a. Aggregate Testing and Mix Proportioning: Aggregate testing and mixture proportioning studies shall be performed by a commercial laboratory.

b. Acceptance Testing: Furnish all materials, labor, and facilities required for molding, curing, testing, and protecting test specimens at the site and in the laboratory. Steel molds shall be used for molding the beam specimens. Furnish and maintain boxes or other facilities suitable for storing and curing the specimens at the site while in the mold within the temperature range stipulated by ASTM C31/C31M. Flexural loading equipment shall be in accordance with ASTM C78/C78M.

c. Contractor Quality Control: All sampling and testing shall be performed by an approved, onsite, independent, commercial laboratory, or for cementitious materials and admixtures, the manufacturer's laboratory. Submit USACE validation letter for commercial laboratory.

d. Laboratory Inspection: The Government will inspect the laboratory equipment and test procedures prior to the start of concreting operations for conformance to ASTM C1077. The laboratory shall maintain this certification for the duration of the project.

1.5.4 Preconstruction Testing of Materials

****
NOTE: Designer must edit this paragraph and following subparagraphs as appropriate. For Design Build Contracts the testing shall be performed by the Contractor utilizing an approved petrographer and commercial testing laboratory. Delete any subparagraphs which are not applicable. Fill in blanks as appropriate.
****

All sampling and testing shall be performed by, and at the expense of, the Contractor. Use an approved commercial laboratory or, for cementitious materials and chemical admixtures, a laboratory maintained by the manufacturer of the material. No material shall be used until notice of acceptance has been given. The Contractor will not be entitled to any additional payment or extension of time due to failure of any material to meet project requirements, or for any additional sampling or testing required. Additional tests may be performed by the Government at the discretion of the Contracting Officer; such Government testing will not relieve the Contractor of any testing responsibilities.

1.5.4.1 Aggregates

Aggregates shall be sampled in the presence of a Government Representative. Samples shall be obtained in accordance with ASTM D75/D75M and shall be representative of the materials to be used for the project. Test results shall be submitted 7 days before commencing mixture proportioning studies.

1.5.4.2 Chemical Admixtures, Curing Compounds and Epoxies

At least 30 days before the material is used, submit certified copies of

test results for the specific lots or batches to be used on the project. Test results shall be not more than 6 months old prior to use in the work. Chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing will be retested at the expense of the Contractor and will be rejected if test results are not satisfactory.

1.5.4.3 Cementitious Materials

Cement[, ground granulated blast furnace (GGBF) slag,] [and pozzolan] will be accepted on the basis of manufacturer's certification of compliance, accompanied by mill test reports showing that the material in each shipment meets the requirements of the specification under which it is furnished. Mill test reports shall be no more than 1 month old, prior to use in the work. No cementitious material shall be used until notice of acceptance has been given by the Contracting Officer. Cementitious material may be subjected to check testing by the Government from samples obtained at the mill, at transfer points, or at the project site. If tests prove that a cementitious material that has been delivered is unsatisfactory, it shall be promptly removed from the site of the work. Cementitious material that has not been used within 6 months after testing shall be retested at the Contractor's expense and shall be rejected if test results are not satisfactory.

1.5.5 Testing During Construction

During construction, the Contractor is responsible for sampling and testing aggregates, cementitious materials, and concrete as specified herein. The Government will sample and test concrete and ingredient materials as considered appropriate. Provide facilities and labor as may be necessary for procurement of representative test samples. Testing by the Government will in no way relieve the Contractor of the specified testing requirements.

1.5.6 Test Section

At least 10 days, but not more than 60 days, prior to construction of the concrete pavement, construct a test section [near the job site, but not as part of the production pavement area.] [as part of the production paving area at an outer edge as indicated on the drawings]. Use the test section to develop and demonstrate to the satisfaction of the Contracting Officer the proposed techniques of mixing, hauling, placing, consolidating, finishing, curing, initial saw cutting, start-up procedures, testing methods, plant operations, and the preparation of the construction joints. Variations in mixture proportions, other than water, shall be made if directed. Vary the water content, as necessary, to arrive at the appropriate content. The mixing plant shall be operated and calibrated prior to start of placing the test section. Use the same equipment, materials, and construction techniques on the test section as will be used in all subsequent work. Base course preparation, concrete production, placing, consolidating, curing, construction of joints, and all testing shall be in accordance with applicable provisions of this specification. Three days after completion of the test section, provide eight cores at least 150 mm 6 inch diameter by full depth cut from points selected in the test section by the Government. The cores will be evaluated for homogeneity, consolidation and segregation. Construct the test section meeting all specification requirements and being acceptable to the Contracting Officer in all aspects, including surface texture. Failure to construct an acceptable test section will necessitate construction of additional test sections at no additional cost to the Government. Test

sections allowed to be constructed as part of the production paving which do not meet specification requirements shall be removed at the Contractor's expense. If the Contractor proposes to use slipform paving and is unable to construct an acceptable test section, the slipform paving equipment shall be removed from the job and the construction completed using stationary side forms and equipment compatible with them. Production paving shall not commence until the results on aggregates and concrete, including evaluation of the cores, and all pavement measurements for edge slump, joint face deformation, actual plan grade, surface smoothness and thickness have been submitted and approved by the Contracting Officer. Pavement accepted as a production lot will be evaluated and paid in accordance with Paragraph: ACCEPTABILITY OF WORK below.

1.5.6.1 Pilot Lane

The test section shall consist of one paving lane at least 130 m 400 feet long and shall be constructed to the same thickness as the thickest portion of pavement shown on the Drawings. The lane width shall be the same as that required for use in the project. The test section shall contain at least one transverse construction joint. If [keyed or]doweled longitudinal construction joints are required in any of the production pavements, they shall be installed full length along one side of the test strip throughout the test section. [If both keys and dowels are required, each shall be installed in half of the test section.] Two separate days shall be used for construction of the test section.

1.5.6.2 Fill-In Lane

The first 130 m 400 feet of the initial production fill-in lane shall be considered a fill-in lane test section for purposes of testing and evaluation. All requirements for the test section are applicable, as appropriate. Obtain cores from the fill-lane lane side of the longitudinal construction joint with the pilot lane. The cores will be evaluated for homogeneity, consolidation, and segregation.

1.5.7 Acceptability of Work

The materials and the pavement itself will be accepted on the basis of tests made by the Contractor. The Government may make check tests to validate the results of the Contractor's testing. If the results of the Contractor tests vary by less than 2.0 percent of the Government's test results, the results of the Contractor's tests will be used. If the results of the Government and Contractor tests vary by 2.0 percent, but less than 4.0 percent, the average of the two will be considered the value to be used. If these vary by 4.0 percent or more, each sampling and testing procedure shall be carefully evaluated and both the Government and the Contractor shall take another series of tests on duplicate samples of material. If these vary by 4.0 percent or more, the results of the tests made by the Government shall be used and the Government will continue check testing of this item on a continuous basis until the two sets of tests agree within less than 4.0 percent on a regular basis. Testing performed by the Government will in no way at any time relieve the Contractor from the specified testing requirements.

1.5.8 Acceptance Requirements

1.5.8.1 Pavement Lots

****

NOTE: The lot size can be specified on the basis of time or volume of production. Normally, it is most practical for construction oversight if a lot is made equal to one shift, but not over 10 hours. If the lot size is based on the amount of production, it should be selected to be approximately equal to the amount of concrete pavement produced in one shift (one day) of operation. The lot size should never exceed 750 cubic meters (1000 cu. yd.) of concrete pavement. When the total job does not exceed 750 cubic meters (1000 cu. yd.), the lot size becomes the total job. The following paragraphs will be edited accordingly. Do not change terminology (computed percent payment, actual percent payment, etc.).

****

A lot will be that quantity of construction that will be evaluated for acceptance with specification requirements. A lot will be equal to one shift of production not to exceed 750 cubic meters 1000 cubic yards. In order to evaluate thickness, each lot will be divided into four equal sublots. Grade determinations will be made on the lot as a whole. Surface smoothness determinations will be made on every 0.1 km 0.1 mile segment in each lot. Location of all samples shall be selected on a random basis in accordance with ASTM D3665. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, the following procedure shall be used to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they shall constitute a lot. Where one or two sublots have been completed, they shall be incorporated into the next lot (except for the last lot), and the total number of sublots shall be used and acceptance criteria adjusted accordingly.

1.5.8.2 Evaluation

Provide all sampling and testing required for acceptance and payment adjustment at the Contractor's expense. Individuals performing sampling, testing and inspection duties shall meet the required Qualifications. The Contracting Officer reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. Testing in these areas will be in addition to the sublot or lot testing, and the requirements for these areas will be the same as those for a sublot or lot. Provide facilities for and, where directed, personnel to assist in obtaining samples for any Government testing.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Bulk Cementitious Materials

Furnish all cementitious material in bulk. The temperature of the cementitious material, as delivered to storage at the site, shall not exceed 65 degrees C 150 degrees F. Sufficient cementitious materials shall be in storage to sustain continuous operation of the concrete mixing plant while the pavement is being placed. Provide separate facilities to prevent any intermixing during unloading, transporting, storing, and handling of each type of cementitious material.

1.6.2 Aggregate Materials

Store aggregate at the site of the batching and mixing plant avoiding breakage, segregation, intermixing or contamination by foreign materials. Each size of aggregate from each source shall be stored separately in free-draining stockpiles. Aggregate stored on ground shall have a minimum 0.6 m 24 inch thick sacrificial layer left undisturbed. Fine aggregate and the smallest size coarse aggregate shall remain in free-draining storage for at least 24 hours immediately prior to use. Sufficient aggregate shall be maintained at the site at all times to permit continuous uninterrupted operation of the mixing plant at the time concrete pavement is being placed. Tracked equipment shall not be allowed on coarse aggregate stockpiles.

1.6.3 Other Materials

Store reinforcing bars and accessories above the ground on supports. All materials shall be stored avoiding contamination and deterioration.

PART 2 PRODUCTS

****
NOTE: Delete any reference to any products which are not to be used on the project. Coordinate all product requirements with the appropriate agency's Pavements or Materials Engineer.
****

2.1 CEMENTITIOUS MATERIALS

****
NOTE: Edit these paragraphs as appropriate for the particular project. Guidance for use of cementitious materials should be sought from the Pavement Materials engineer or from the TSMCX, Air Force MAJCOM paving engineers, or NAVFAC, especially for areas subject to alkali-aggregate reactivity, or sulfate attack.

When sulfate bearing soil or water is encountered, specify Type II cement for moderate sulfate concentration and Type V cement for high concentration and consider requiring use of fly ash or GGBF slag for partial replacement. Do not specify Type I or III cement. See UFC 3-250-04FA for guidance. Specify limit on false set if it is a problem in the area.

Type III cement should not be specified unless accelerated paving is involved and then only after laboratory mixture proportioning studies and tests during the design stage of the project.
****

Cementitious materials shall be portland cement, [blended cement] or only portland cement in combination with supplementary cementitious materials (SCM), and shall conform to appropriate specifications listed below. New submittals are required when the cementitious materials sources or types change.

2.1.1 Portland Cement

Provide portland cement conforming to ASTM C150/C150M, Type [I] [II] [V], low alkali [including false set requirements]. [Type III cement shall be used only in concrete in the following locations [_____].] Low alkali cement is required if the proposed aggregates are found to have greater than 0.04 percent expansion when tested in accordance with paragraph: Alkali-Silica Reactivity below.

2.1.2 Blended Cements

Blended cement shall conform to ASTM C595/C595M, Type IP or IS, including the optional requirement for mortar expansion [and sulfate soundness]. The pozzolan added to the Type IP blend shall be ASTM C618 Class F or Class N and shall be interground with the cement clinker. The manufacturer shall state in writing that the amount of pozzolan in the finished cement will not vary more than plus or minus 5 mass percent of the finished cement from lot to lot or within a lot. The percentage and type of mineral admixture used in the blend shall not change from that submitted for the aggregate evaluation and mixture proportioning.

2.1.3 Pozzolan

2.1.3.1 Fly Ash

****

NOTE: Class C fly ash is not permitted for paving concrete.

Use loss on ignition not exceeding 3 percent for frost areas to reduce carbon interference with air entraining admixture.

****

Fly ash shall conform to ASTM C618, Class F, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding [3] [6] percent. Class F fly ash for use in mitigating Alkali-Silica Reactivity shall have a Calcium Oxide (CaO) content of less than 13 percent and a total equivalent alkali content less than 3 percent.

2.1.3.2 Raw or Calcined Natural Pozzolan

Natural pozzolan shall be raw or calcined and conform to ASTM C618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding [3] [6] percent. Class N pozzolan for use in mitigating Alkali-Silica Reactivity shall have a Calcium Oxide (CaO) content of less than 13 percent and a total equivalent alkali content less than 3 percent.

2.1.3.3 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) shall conform to ASTM C618, Class F or N, and the following additional requirements:

a. The strength activity index at 28 days of age shall be at least 95 percent of the control specimens.

b. The average particle size shall not exceed 6 microns.

c. The sum of SiO2 + Al2O3 + Fe2O3 shall be greater than 77 percent.

2.1.4 Ground Granulated Blast-Furnace (GGBF) Slag

Ground Granulated Blast-Furnace Slag shall conform to ASTM C989/C989M, [Grade 100 or] Grade 120.

2.1.5 Silica Fume

****
NOTE: Silica Fume shall only be used for OCONUS projects where Class F fly ash and GGBF slag are not available, and when approved by the TSMCX, Air Force major command (MAJCOM) pavement engineers, or NAVFAC. Delete this paragraph here and where encountered throughout the remainder of this section.
****

Silica fume shall conform to ASTM C1240, including the optional limits on reactivity with cement alkalis. Silica fume may be furnished as a dry, densified material or as a slurry. Provide at the Contractor's expense the services of a manufacturer's technical representative, experienced in mixing, proportioning, placement procedures, and curing of concrete containing silica fume. This representative must be present on the project prior to and during at least the first 4 days of concrete production and placement using silica fume.

2.1.6 Supplementary Cementitious Materials (SCM) Content

****
NOTE: Use first tailoring option for Navy projects. Use second tailoring option for Army/Air Force projects.
****

[The concrete mix shall always contain one of the SCMs listed in Table 2 within the range specified therein, whether or not the aggregates are found to be reactive in accordance with paragraph Alkali Silica Reactivity.][The Contractor may elect to use one of the SCMs listed below, unless the SCM is required to mitigate ASR. The use of SCMs is encouraged in accordance with Section 01 62 35, Recycled/Recovered Materials.]

TABLE 2
SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT

Supplementary Cementitious Material	Minimum Content	Maximum Content
Class N Pozzolan and Class F Fly Ash		
SiO2 + Al2O3 + Fe2O3 > 70%	25%	35%
Si02 + A1203 + Fe203 > 80%	20%	35%
Si02 + A1203 + Fe203 > 90%	15%	35%
UFFA and UFP	7%	16%
GGBF Slag	40%	50%
Silica Fume	7%	10%

2.2 AGGREGATES

****
NOTE: The designer will ensure that aggregates available in the area meet the requirements of these specifications. Otherwise, the specification requirements must be modified to allow use of available material. This concern must be discussed and validated in the Design Analysis before preparation of the project specifications. During the design stage, the designer must assure that all aggregate materials in the area which meet the project specifications will also produce concrete of the specified flexural strength with a reasonable cementitious material content. Otherwise, specifications and design assumptions must be modified. It is imperative that all aggregate be investigated for problems related to alkali-aggregate reactions.
****

2.2.1 Aggregate Sources

2.2.1.1 Durability

****
NOTE: Use first Tailoring Option for Army and Air Force; second option is for Navy projects only.
****

Aggregate shall have a satisfactory service record in freezing and thawing of at least 5 years successful service in three concrete paving projects. The service record shall include a condition survey of the existing concrete and a review of the concrete-making materials, including coarse and fine aggregates, cement, and mineral admixtures. This review should consider the previous aggregate source and test results, cement mill certificate data, mineral admixture chemical and physical composition, and the mix design (cement factor and water-cementitious material ratio). Aggregate not having a satisfactory demonstrable service record shall have a durability factor of 50 or more when subjected to freezing and thawing of specimens prepared in accordance with ASTM C1646/C1646M and tested in accordance with ASTM C666/C666M, Procedure A. Fine and coarse aggregates to be used in all concrete shall be evaluated and tested for durability in accordance with ASTM C88. Results shall not show more than 18 percent loss when subjected to 5 cycles using Magnesium Sulfate. If Sodium Sulfate is used, results shall not show more than 12 percent loss when subjected to 5 cycles.

2.2.1.2 Alkali-Silica Reactivity

****
NOTE: Do not include Lithium Nitrate in a project specification without TSMCX, NAVFAC or Air Force MAJCOM pavement engineer's concurrence.
****

Fine and coarse aggregates to be used in all concrete shall be evaluated and tested for alkali-aggregate reactivity. Both coarse aggregate size groups shall be tested.

a. The fine and coarse aggregates shall be evaluated separately, using ASTM C1260. Test results of the individual aggregates shall have a measured expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Should the test data indicate an expansion of greater than 0.08 percent, the aggregate(s) shall be rejected or additional testing shall be performed as follows: utilize the Contractor's proposed low alkali portland cement, blended cement, and/or SCM, and/or Lithium Nitrate in combination with each individual aggregate. If only SCMs are being evaluated, the testing shall be in accordance with ASTM C1567. If Lithium Nitrate is being evaluated, with or without SCMs, the testing shall be in accordance with COE CRD-C 662. Determine the quantity that will meet all the requirements of these specifications and that will lower the expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Mixture proportioning shall be based on the highest percentage of SCM required to mitigate ASR-reactivity

b. If any of the above options does not lower the expansion to less than 0.08 percent after 28 days of immersion in a 1N NaOH solution, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing to the Contracting Officer for evaluation and acceptance.

2.2.1.3 Accelerated Alkali-Silica Reactivity

****

NOTE: The use of pavement de-icing and anti-icing compounds has been identified with accelerated Alkali-Silica Reactivity. The base's use of de-icing and anti-icing compounds must be identified. If these products are used, a second ASR evaluation must be performed, using the de-icing/anti-icing compounds as the soak agent, per the referenced IPRF methodology. Remove the brackets on the following paragraphs to include the test requirements.

****

[For concrete anticipated to be exposed to deicer chemicals during its service life, fine and coarse aggregates to be used in the concrete shall be evaluated and tested for alkali-aggregate reactivity in accordance with the IPRF INTERIM TEST PROTOCOL. Liquid anti-icing solutions shall be of the type and concentration used by the facility. Solid deicing chemicals shall be used at a concentration that represents a room-temperature saturated solution. Evaluation of the aggregates and mitigation alternatives shall be in accordance with the previous requirements. Test results shall have a measured expansion equal to or less than 0.08 percent at 28 days of immersion in the soak solution. Should the test data indicate an expansion of greater than 0.08 percent, the aggregate(s) shall be rejected. Mixture proportioning shall be based on the highest percentage of SCM required to mitigate ASR-reactivity, as determined from either the sodium hydroxide or deicer compound test series.]

2.2.1.4 Combined Aggregate Gradation

In addition to the grading requirements specified for coarse aggregate and for fine aggregate, the combined aggregate grading shall meet the following requirements:

a. The materials selected and the proportions used shall be such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in d. below, the point thus determined shall fall within the parallelogram described therein.

b. The Coarseness Factor (CF) shall be determined from the following equation:

CF = (cumulative percent retained on the 9.5 mm sieve)(100)/(cumulative percent retained on the 2.36 mm sieve) CF = (cumulative percent retained on the 3/8 in. sieve)(100)/(cumulative percent retained on the No. 8 sieve)

c. The Workability Factor WF is defined as the percent passing the 2.36 mm No. 8 sieve based on the combined gradation. However, WF shall be adjusted, upwards only, by 2.5 percentage points for each 42 kg 94 pounds of cementitious material per cubic meter yard greater than 335 kg per cubic meter 564 pounds per cubic yard.

d. A diagram shall be plotted using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram a parallelogram shall be plotted with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, the grading of each size of aggregate used and the proportions selected shall be changed as necessary.)

2.2.2 Coarse Aggregate

2.2.2.1 Material Composition

****

NOTE: Crushing gravel tends to improve quality and bond characteristics and generally results in higher flexural strength of concrete. When mixture proportioning studies or local experience indicates that low flexural strength concrete will be produced with an uncrushed gravel, the possibility of producing higher strength concrete by crushing the gravel should be investigated. When desirable to limit coarse aggregate to crushed materials, modify this paragraph appropriately.

Do not, under any conditions, permit use of steel furnace slag for any aggregate. (It is markedly different from iron blast furnace slag.)

In power check pads, the high temperatures from jet blast can cause distress in aggregates in the concrete. Include bracketed item if power check pads are to be constructed. If no service record is available, lab study of available aggregates should be made. Only basalt is permitted on Navy projects.

Special attention should be given to aggregates to be used for compass calibration pads. Aggregates

with magnetic properties, such as, but not limited to, magnetite in granites, high-iron minerals in traprock, pyrite in limestone, and free iron or iron oxide in slag aggregate should not be used. When the paving of compass calibration pads is required, add the bracketed item concerning compass pads as additional requirements for coarse and fine aggregates.

Retain the bracketed requirement for washing coarse aggregate if aggregates in the area require it. Add the requirement to use a log washer or other specific equipment if experience in the area shows the need. Delete if not needed. It is permissible to list certain aggregate sources that do not require washing, if that is appropriate. The designer must make the decision during preparation of specifications; do not make the Resident Engineer decide after award if aggregates need to be washed.

****

Coarse aggregate shall consist of crushed or uncrushed gravel, crushed stone, [crushed adequately seasoned air-cooled iron blast-furnace slag; steel furnace slag will not be permitted], or a combination thereof. [Aggregate used for paving compass calibration hardstands shall be free of materials having undesirable magnetic properties, including magnetite in granite, high-iron minerals in traprock, and pyrite in limestone.] [Coarse aggregate used for paving power check pads shall be limestone, dolomite, basalt or other approved low-silica content aggregate which will not cause thermal distress from jet blast.] Aggregates, as delivered to the mixers, shall consist of clean, hard, uncoated particles meeting the requirements of ASTM C33/C33M except as specified herein. [Coarse aggregate shall be washed. Washing shall be sufficient to remove dust and other coatings.] [Coarse aggregate shall be cleaned by processing with an approved log washer.] [Iron blast-furnace slag conforming to the grading to be used in the concrete shall have a compact density of not less than 1125 kg/cubic meter 70 lb/cu. ft. determined in accordance with ASTM C29/C29M]. Coarse aggregate shall not show more than 40 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 12 percent, or the magnesium sulfate soundness loss shall not exceed 18 percent after five cycles when tested in accordance with ASTM C88.

2.2.2.2 Particle Shape Characteristics

Particles of the coarse aggregate shall be generally spherical or cubical in shape. The quantity of flat and elongated particles in any size group coarser than the 9.5 mm3/8 inch sieve shall not exceed 20 percent by weight as determined by the Flat Particle Test and the Elongated Particle Test of ASTM D4791. A flat particle is defined as one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3.

2.2.2.3 Size and Grading

****

NOTE: Fill in the blank according to the size aggregate available in the project area, and the type of paving. For thin bonded overlays, limit the

nominal maximum aggregate size to less than one-third of the uniform overlay thickness (not including leveling portion). Use nominal maximum aggregate size of 37.5 mm (1-1/2 inch) whenever possible. A 25 mm (1-inch) nominal maximum aggregate size may be used to avoid durability problems associated with some larger size aggregate.

****

The nominal maximum size of the coarse aggregate shall be 37.5 [_____] mm 1.5 [_____] inch. The individual aggregates shall be graded and furnished in size groups to meet the coarseness and workability factor criteria for the contractor-proposed combined gradation.

2.2.2.4 Deleterious Materials - Airfield Pavements

****

NOTE: Include these deleterious material requirements for airfield paving projects only, otherwise, delete. In Table 5 select columns showing appropriate percentage by weight in accordance with the following. Delete the inapplicable column in the table and the heading of the column used.

Weather Severity	Air Freezing Index Coldest year in 30 (a)	Average Precipitation for any Single Month during the Freezing Period
Moderate	500 or less	Any Amount
Moderate (b)	501 or more	Less than 25 mm (1 inch)
Severe	501 or more	25 mm (1 inch) or more

(a) Calculated as described in UFC 3-130-01. See ASTM C33/C33M for simplified map of CONUS weather severity.

(b) In poorly drained areas, the weather should be considered severe even though the other criteria indicate a rating of moderate.

(c) For Navy projects, select "Negligible Weather" column of Table 5. Delete the inapplicable columns and delete paragraphs a through h.

****

The amount of deleterious material in each size group of coarse aggregate shall not exceed the limits shown in Table 5 below, determined in accordance with the test methods shown.

TABLE 5
LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE
FOR AIRFIELD PAVEMENTS
Percentage by Mass

Materials [h]	Severe Weather	Moderate Weather	Negligible Weather
Clay lumps and friable particles (ASTM C142/C142M)	0.2	0.2	1.0
Shale (a) (ASTM C295/C295M)	0.1	0.2	--
Material finer than 0.075 mm (No. 200 sieve) (b) (ASTM C117)	0.5	0.5	1.0
Lightweight particles (c) (ASTM C123/C123M)	0.2	0.2	1.0
Clay ironstone (d) (ASTM C295/C295M)	0.1	0.5	--
Chert and cherty stone (less than 2.40 Mg/cubic meter density SSD (2.40 Sp. Gr.)) (e) (ASTM C123/C123M) and ASTM C295/C295M)	0.1	0.5	--
Claystone, mudstone, and siltstone (f) (ASTM C295/C295M)	0.1	0.1	--
Shaly and argillaceous limestone (g) (ASTM C295/C295M)	0.2	0.2	--
Other soft particles (COE CRD-C 130)	1.0	1.0	1.0
Total of all deleterious substances exclusive of material finer than 0.075 mm (No. 200 sieve)	1.0	2.0	3.0

a. Shale is defined as a fine-grained, thinly laminated or fissile sedimentary rock. It is commonly composed of clay or silt or both. It has been indurated by compaction or by cementation, but not so much as to have become slate.

b. Limit for material finer than 0.075 mm (No. 200 sieve) will be increased to 1.5 percent for crushed aggregates if the fine material consists of crusher dust that is essentially free from clay or shale. Use ASTM D2419, if required, to differentiate between crusher dust and clay/shale.

c. The separation medium shall have a density of 2.0 Mg/cubic meter (Sp. Gr. of 2.0). This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.

d. Clay ironstone is defined as an impure variety of iron carbonate, iron oxide, hydrous iron oxide, or combinations thereof, commonly mixed with clay, silt, or sand. It commonly occurs as dull, earthy particles, homogeneous concretionary masses, or hard-shell particles with soft interiors. Other names commonly used for clay ironstone are "chocolate bars" and limonite concretions.

e. Chert is defined as a rock composed of quartz, chalcedony or opal, or any mixture of these forms of silica. It is variable in color. The texture is so fine that the individual mineral grains are too small to be distinguished by the unaided eye. Its hardness is such that it scratches glass but is not scratched by a knife blade. It may contain impurities such as clay, carbonates, iron oxides, and other minerals. Cherty stone is defined as any type of rock (generally limestone) that contains chert as lenses and nodules, or irregular masses partially or completely replacing the original stone.

f. Claystone, mudstone, or siltstone, is defined as a massive fine-grained sedimentary rock that consists predominantly of indurated clay or silt without laminations or fissility. It may be indurated either by compaction or by cementation.

g. Shaly limestone is defined as limestone in which shale occurs as one or more thin beds or laminae. These laminae may be regular or very irregular and may be spaced from a few inches down to minute fractions of an inch. Argillaceous limestone is defined as a limestone in which clay minerals occur disseminated in the stone in the amount of 10 to 50 percent by weight of the rock; when these make up from 50 to 90 percent, the rock is known as calcareous (or dolomitic) shale (or claystone, mudstone, or siltstone).

h. Testing shall be performed in accordance with the referenced test methods, except that the minimum sample size shall be as specified below.

2.2.2.5 Testing Sequence/Deleterious Materials - Airfields Only

****
NOTE: Contact TSMCX for guidance on available petrographers in USACE. Use Tailoring Option to select between Navy and Army/Air Force sampling and testing protocols.
****

The Contractor will not be entitled to any extension of time or additional payment due to any delays caused by the testing, evaluation, or personnel requirements. Sample sizes shall be in accordance with the referenced test methods. The size of the coarse aggregate sample shall be at least 90 kg 200 pounds for the 19 mm 3/4 inch and larger maximum size and 12 kg 25 pounds for the 4.75 to 19 mm No. 4 to 3/4 inch coarse aggregate and 5 kg 10 pounds for the fine aggregate. Provide facilities for the ready procurement of representative test samples. The testing procedure on each sample of coarse aggregate for compliance with limits on deleterious materials shall be as follows:

Step 1: Wash each full sample of coarse aggregate for material finer than the 0.075 mm No. 200 sieve. Discard material finer than the 0.075 mm No. 200 sieve.

Step 2: Test remaining full sample for clay lumps and friable particles and remove.

Step 3: Test remaining full sample for lightweight particles (Sp.Gr.2.0) and remove.

Step 4. Test remaining full sample for chert and/or cherty stone with SSD density of less than 2.40 Mg/cubic meter (Sp. Gr. 2.40). Remove lightweight chert and/or cherty stone. Restore other materials less than 2.40 to the sample.

Step 5: Test remaining sample for clay-ironstone, shale, claystone, mudstone, siltstone, shaly and/or argillaceous limestone, and remove.

Step 6: Test approximately one-fifth of remaining full sample for other soft particles.

2.2.2.6 Deleterious Material - Road Pavements

****
NOTE: Use this paragraph only for heavy-duty pavements, roads, streets, and parking lots for vehicular and tracked traffic. Otherwise, delete.
****

The amount of deleterious material in each size group of coarse aggregate shall not exceed the limits in the following table when tested as indicated.

LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR ROAD PAVEMENTS
Percentage by Mass

Clay lumps and friable particles (ASTM C142/C142M)	2.0
Material finer than 0.075 mm (No. 200 sieve) (ASTM C117)	1.0
Lightweight particles (ASTM C123/C123M)	1.0
Other soft particles (COE CRD-C 130)	2.0
Total of all deleterious substances, exclusive of material finer than 0.075 mm No. 200 sieve	5.0

The limit for material finer than the 0.075 mm No. 200 sieve will be increased to 1.5 percent for crushed aggregates consisting of crusher dust that is essentially free from clay or shale. The separation medium for lightweight particles shall have a density of 2.0 Mg/cubic meter Sp. Gr. 2.0. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.

2.2.3 Fine Aggregate

2.2.3.1 Composition

Fine aggregate shall consist of natural sand, manufactured sand, or a combination of the two, and shall be composed of clean, hard, durable particles meeting the requirements of ASTM C33/C33M. [Aggregate used for paving compass calibration hardstands shall be free of materials having undesirable magnetic properties, including magnetite in granite, high-iron minerals in traprock, and pyrite in limestone.] Each type of fine aggregate shall be stockpiled and batched separately. Particles of the fine aggregate shall be generally spherical or cubical in shape.

2.2.3.2 Grading

Grading of the fine aggregate, as delivered to the mixer, shall conform to the requirements of ASTM C33/C33M and shall have a fineness modulus of not less than 2.50 nor more than 3.00.

2.2.3.3 Deleterious Material

The amount of deleterious material in the fine aggregate shall not exceed the following limits by mass:

Material	Percentage by Mass
Clay lumps and friable particles ASTM C142/C142M	1.0
Material finer than 0.075 mm (No. 200 sieve) ASTM C117	3.0
Lightweight particles ASTM C123/C123M using a medium with a density of 2.0 Mg/cubic meter (Sp. Gr. of 2.0))	0.5
Total of all above	3.0

2.3 CHEMICAL ADMIXTURES

2.3.1 General Requirements

Chemical admixtures may only be used when the specific admixture type and manufacturer is the same material used in the mixture proportioning studies. The air-entraining admixture shall conform to ASTM C260/C260M. An accelerator conforming to ASTM C494/C494M, Type C, may be used only when specified in paragraph: SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES below and shall not be used to reduce the amount of cementitious material used. Calcium chloride and admixtures containing calcium chloride shall not be used. Retarding or water-reducing admixture shall meet the requirements of ASTM C494/C494M, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived. ASTM C494/C494M, Type F and G high range water reducing admixtures and ASTM C1017/C1017M flowable admixtures shall not be used.

2.3.2 Lithium Nitrate

****

NOTE: Contact the TSCMX, NAVFAC or Air Force MAJCOM pavement engineers before specifying Lithium Nitrate to mitigate Aggregate-Silica Reaction (ASR).

Coordinate with manufacturer regarding Lithium Nitrate dosage.

****

The lithium admixture shall be a nominal 30 percent aqueous solution of Lithium Nitrate, with a density of 1.2 kg/L 10 pounds/gallon, and shall have the approximate chemical form as shown below:

Constituent	Limit (Percent by Mass)
$LiNo_3$ (Lithium Nitrate)	30 +/- 0.5
SO_4^{-2} (Sulfate Ion)	0.1 (max)
Cl^- (Chloride Ion)	0.2 (max)
Na^+ (Sodium Ion)	0.1 (max)
K^+ (Potassium Ion)	0.1 (max)

The Lithium Nitrate manufacturer shall provide a trained representative to supervise the lithium nitrate admixture dispensing and mixing operations.

2.3.3 High Range Water Reducing Admixture (HRWRA)

****

NOTE: High Range Water Reducing Admixtures are permitted only when using Silica Fume. Delete for all other projects

****

A high-range water-reducing admixture shall meet the requirements of ASTM C494/C494M, Type F or G. The HRWRA shall be free from chlorides, alkalis, and shall be of the synthesized, sulfonated complex polymer type. The HRWRA shall be added to the concrete as a single component at the batch plant. The admixture shall be added to the concrete mixture only when its use is approved or directed, and only when it has been used in mixture proportioning studies to arrive at approved mixture proportions. Submit certified copies of the independent laboratory test results required for compliance with ASTM C494/C494M.

2.4 MEMBRANE FORMING CURING COMPOUND

****

NOTE: ASTM C309 may be used for roads and streets and Navy airfield pavements. Use CRD-C 300 for Army or Air Force airfield pavement projects.

****

Membrane forming curing compound shall [be a white pigmented compound conforming to COE CRD-C 300.] [conform to ASTM C309, white-pigmented Type 2, Class B].

2.5 WATER

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water, or water from concrete production operations, may be used if it meets the requirements of ASTM C1602/C1602M.

2.6 JOINT MATERIALS

****

NOTE: Edit as appropriate for project requirements. Coordinate with Section 32 01 19 for Army projects and 32 13 73 for all other projects.

****

2.6.1 Expansion Joint Material

Expansion joint filler shall be a preformed material conforming to [ASTM D1751] [or] [ASTM D1752 Type [II] [III].] Expansion joint filler shall be 19 mm 3/4 inch thick, unless otherwise indicated, and shall be furnished in a single full depth piece.

2.6.2 Slip Joint Material

Slip joint material shall be 6 mm 1/4 inch thick expansion joint filler, unless otherwise indicated, conforming to paragraph: Expansion Joint Material.

2.7 REINFORCING

****

NOTE: Edit these paragraphs to conform to project requirements. Delete those not needed. Add epoxy-coated bars (ASTM A775/A775M) or low-alloy bars (ASTM A706/A706M) when required by design.

****

All reinforcement shall be free from loose, flaky rust, loose scale, oil, grease, mud, or other coatings that might reduce the bond with concrete. Removal of thin powdery rust and tight rust is not required. However, reinforcing steel which is rusted to the extent that it does not conform to the required dimensions or mechanical properties shall not be used.

2.7.1 Reinforcing Bars and Bar Mats

Reinforcing bars shall conform to [ASTM A615/A615M, billet-steel] [ASTM A996/A996M, rail and axle steel], Grade 60 [_____]. Bar mats shall conform to ASTM A184/A184M. The bar members may be billet rail or axle steel.

2.7.2 Welded Wire Reinforcement

Welded Wire Reinforcement shall be deformed or smooth, conforming to ASTM A497/A497Mor ASTM A185/A185M, and shall be furnished in flat sheets.

2.8 DOWELS AND TIE BARS

****

NOTE: Retain paragraph on dowels. Even if not required, design should normally allow dowels as an option. Edit tie bars as required by design.

****

2.8.1 Dowels

Dowels shall be single piece bars fabricated or cut to length at the shop or mill before delivery to the site. Dowels shall be free of loose, flaky rust and loose scale and shall be clean and straight. Dowels may be sheared to length provided that the deformation from true shape caused by

shearing does not exceed 1 mm 0.04 inch on the diameter of the dowel and does not extend more than 1 mm 0.04 inch from the end of the dowel. Dowels shall be plain (non-deformed) steel bars conforming to ASTM A615/A615M, Grade 40 or 60; ASTM A996/A996M, Grade 50 or 60. Dowel bars shall be epoxy coated in conformance with ASTM A775/A775M. Grout retention rings shall be fully circular metal or plastic devices capable of supporting the dowel until the epoxy hardens. Dowel sleeves or inserts are not permitted.

2.8.2 Dowel Bar Assemblies

Dowel bar assemblies shall consist of a framework of metal bars or wires arranged to provide rigid support for the dowels throughout the paving operation, with a minimum of four continuous bars or wires extending along the joint line. The dowels shall be welded to the assembly or held firmly by mechanical locking arrangements that will prevent them from rising, sliding out, or becoming distorted during paving operations.

2.8.3 Tie Bars

Tie bars shall be deformed steel bars conforming to ASTM A615/A615M, or ASTM A996/A996M, Grade 60 [_____], and of the sizes and dimensions indicated. Deformed rail steel bars and high-strength billet or axle steel bars, Grade 50 or higher, shall not be used for bars that are bent and straightened during construction.

2.9 EPOXY RESIN

All epoxy-resin materials shall be two-component materials conforming to the requirements of ASTM C881/C881M, Class as appropriate for each application temperature to be encountered, except that in addition, the materials shall meet the following requirements:

a. Material for use for embedding dowels and anchor bolts shall be Type IV, Grade 3.

b. Material for use as patching materials for complete filling of spalls and other voids and for use in preparing epoxy resin mortar shall be Type III, Grade as approved.

c. Material for use for injecting cracks shall be Type IV, Grade 1.

d. Material for bonding freshly mixed portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete shall be Type V, Grade as approved.

2.10 EQUIPMENT

All plant, equipment, tools, and machines used in the work shall be maintained in satisfactory working conditions at all times. Submit the following:

a. Details and data on the batching and mixing plant prior to plant assembly including manufacturer's literature showing that the equipment meets all requirements specified herein.

b. A certified copy of the NRMCA QC Manual Section 3 Concrete Plant Certification Checklist and Calibration documentation on all measuring and weighing devices, submitted prior to uniformity testing.

c. A description of the equipment proposed for transporting concrete mixture from the central mixing plant to the paving equipment.

d. A description of the equipment proposed for the machine and hand placing, consolidating and curing of the concrete mixture. Manufacturer's literature on the paver and finisher, together with the manufacturer's written instructions on adjustments and operating procedures necessary to assure a tight, smooth surface on the concrete pavement. The literature shall show that the equipment meets all details of these specifications. [Detailed information on automatic laser controlled systems shall be submitted if proposed for use.]

2.10.1 Batching and Mixing Plant

****

NOTE: The batching and mixing plant should be on the construction site or as close as possible, but should be no farther than 15 minutes haul time from the placing site during all periods of the work day. Verify the availability of water and electrical power for sites on Government land. On Navy projects, specify an off-site batch plant. Edit bracketed items as appropriate.

Plant capacity should be governed by the laydown pattern or the size of the job to prevent delay of paving operations.

****

a. Location: The batching and mixing plant shall be located [on project site as indicated on the drawings] [off Government premises no more than 15 minutes haul time from the placing site]. [Water and electrical power [are] [are not] available on the project site.] There shall be operable telephonic or radio communication between the plant and the placing site at all times concreting is taking place.

b. Type and Capacity: The batching and mixing plant shall be a stationary-type central mix plant, including permanent installations or portable/relocatable plants installed on stable foundations. The plant shall be designed and operated to produce concrete within the specified tolerances, and shall have a capacity of at least 200 cubic meters 250 cubic yards [_____] per hour. The batching and mixing plant shall conform to the requirements of NRMCA QC 3 including provisions addressing:

1. Material Storage and Handling
2. Batching Equipment
3. Central Mixer
4. Ticketing System
5. Delivery System

c. Tolerances: The following tolerances shall apply.

Materials	Percentage of Required Mass
Cementitious Materials	plus or minus 1
Aggregate	plus or minus 2
Water	plus or minus 1
Admixture	plus or minus 3

For volumetric batching equipment for water and admixtures, the above numeric tolerances shall apply to the required volume of material being batched. Concentrated admixtures shall be uniformly diluted, if necessary, to provide sufficient volume per batch to ensure that the batchers will consistently operate within the above tolerance.

****
NOTE: Edit as appropriate for project. Electric moisture meters should be required for large paving jobs.
****

d. Moisture Control: The plant shall be capable of ready adjustment to compensate for the varying moisture contents of the aggregates and to change the quantities of the materials being batched. [An electric moisture meter complying with the provisions of COE CRD-C 143 shall be provided for measuring of moisture in the fine aggregate. The sensing element shall be arranged so that measurement is made near the batcher charging gate of the fine aggregate bin or in the fine aggregate batcher.]

2.10.2 Concrete Mixers

a. General: Mixers shall be stationary or truck mixers. Mixers shall be capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. The mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Mixer blades or paddles shall be replaced when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades or paddles.

b. Stationary: Stationary mixers shall be drum or pan mixers. Mixers shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed.

c. Mixing Time and Uniformity for Stationary Mixers: For stationary mixers, before uniformity data are available, the mixing time for each batch after all solid materials are in the mixer, provided that all of the mixing water is introduced before one-fourth of the mixing time has elapsed, shall be 1 minute for mixers having a capacity of 0.75 cubic meter 1 cubic yard. For mixers of greater capacity, this minimum time shall be increased 20 seconds for each additional cubic meter 1.33 cubic yard or fraction thereof. After results of uniformity tests are available, the mixing time may be reduced to the minimum time required to meet uniformity requirements; but if uniformity requirements are not being met, the mixing time shall be increased as directed. The mixing time for full batch production shall be a minimum of 75 seconds. Mixer

performance tests at new mixing times shall be performed immediately after any change in mixing time. The Regular Test sequence shall be conducted for initial determination of the mixing time or as directed. When regular testing is performed, the concrete shall meet the limits of any five of the six uniformity requirements listed in Table 1 below.

d. The Abbreviated Test sequence shall be conducted for production concrete verification at the frequency specified in Table 6. When abbreviated testing is performed, the concrete shall meet only those requirements listed for abbreviated testing. The concrete proportions used for uniformity tests shall be as used on the project. Regular testing shall consist of performing all six tests on three batches of concrete. The range for regular testing shall be the average of the ranges of the three batches. Abbreviated testing shall consist of performing the three required tests on a single batch of concrete. The range for abbreviated testing shall be the range for one batch. If more than one mixer is used and all are identical in terms of make, type, capacity, condition, speed of rotation, etc., the results of tests on one of the mixers shall apply to the others, subject to the approval of the Contracting Officer. All mixer performance (uniformity) testing shall be performed in accordance with COE CRD-C 55 and with paragraph titled TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3.

TABLE 1
UNIFORMITY REQUIREMENTS--STATIONARY MIXERS

Parameter	Regular Tests Allowable Maximum Range for Average of 3 Batches	Abbreviated Tests Allowable Maximum Range for 1 Batch
Unit weight of air-free mortar	32 kg/cubic m	32 kg/cubic m
(Unit weight of air-free mortar	2.0 lbs/cubic ft	2.0 lbs/cubic ft)
Air content	1.0 percent	--
Slump	25 mm	25 mm
(Slump	1.0 inch	1.0 inch)
Coarse aggregate	6.0 percent	6.0 percent
Compressive strength at 7 days,	10.0 percent	10.0 percent
Water content	1.5 percent	

e. Truck: Truck mixers shall not be used for mixing or transporting slipformed paving concrete. The only truck mixers used for mixing or transporting paving concrete shall be those designed with extra large blading and rear opening specifically for low-slump paving concrete. Truck mixers, the mixing of concrete therein, and concrete uniformity and testing thereof shall conform to the requirements of ASTM C94/C94M. The number of revolutions between 70 to 100 for truck-mixed concrete and the number of revolutions for shrink-mixed concrete shall be determined by uniformity tests as specified in ASTM C94/C94M and in requirements for mixer performance stated in paragraph TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3. If requirements for the uniformity of concrete are not met with 100 revolutions of

mixing after all ingredients including water are in the truck mixer drum, the mixer shall not be used until the condition is corrected. Water shall not be added after the initial introduction of mixing water except, when on arrival at the job site, the slump is less than specified and the water-cement ratio is less than that given as a maximum in the approved mixture. Additional water may be added to bring the slump within the specified range provided the approved water-cement ratio is not exceeded. Water shall be injected into the head of the mixer (end opposite the discharge opening) drum under pressure, and the drum or blades shall be turned a minimum of 30 additional revolutions at mixing speed. Water shall not be added to the batch at any later time.[Mixer performance (uniformity) tests for truck mixers shall be made in accordance with ASTM C94/C94M.]

2.10.3 Transporting Equipment

Slipform concrete shall be transported to the paving site in nonagitating equipment conforming to ASTM C94/C94M or in approved agitators. Fixed form concrete shall be transported in approved truck mixers designed with extra large blading and rear opening specifically for low slump concrete. All transporting equipment shall be designed and operated to deliver and discharge the required concrete mixture completely without segregation.

2.10.4 Transfer and Spreading Equipment

****
NOTE: A transfer spreader is required for all Army and Air Force airfield paving projects. Delete this paragraph for Navy projects. Coordinate with Part 3 requirements in sub-paragraph: Traffic on Underlying Material.
****

Equipment for transferring concrete from the transporting equipment to the paving lane in front of the paver shall be specially manufactured, self-propelled transfer equipment which will accept the concrete outside the paving lane and will transfer and spread it evenly across the paving lane in front of the paver and strike off the surface evenly to a depth which permits the paver to operate efficiently.

2.10.5 Paver-Finisher

a. General: The paver-finisher shall be a heavy-duty, self-propelled machine designed specifically for paving and finishing high quality pavement. The paver-finisher shall weigh at least 3280 kg/m 2200 lb/foot of lane width, and shall be powered by an engine having at least 15,000 W/m 6.0 horsepower/foot of lane width. The paver-finisher shall spread, consolidate, and shape the plastic concrete to the desired cross section in one pass. The mechanisms for forming the pavement shall be easily adjustable in width and thickness and for required crown. In addition to other spreaders required by paragraph above, the paver-finisher shall be equipped with a full width knock-down auger or paddle mechanism, capable of operating in both directions, which will evenly spread the fresh concrete in front of the screed or extrusion plate.

b. Vibrators: Immersion vibrators shall be gang mounted at the front of the paver on a frame equipped with suitable controls so that all vibrators can be operated at any desired depth within the slab or

completely withdrawn from the concrete, as required. The vibrators shall be automatically controlled so that they will be immediately stopped as forward motion of the paver ceases. [The paver-finisher shall be equipped with an electronic vibrator monitoring device displaying the operating frequency of each individual internal vibrator. The monitoring device shall have a readout display visible to the paver operator. It shall operate continuously while paving, and shall display all vibrator frequencies with manual or automatic sequencing among all individual vibrators.] The spacing of the immersion vibrators across the paving lane shall be as necessary to properly consolidate the concrete, but the clear distance between vibrators shall not exceed 750 mm 30 inches. The outside vibrators shall not be more than 300 mm 12 inches from the lane edge. Spud vibrators shall operate at a frequency of not less than 135 Hz 8000 impulses/minute and an amplitude of not less than 0.75 mm 0.03 inch, as determined by COE CRD-C 521.

c. Screed or Extrusion Plate: The paver-finisher shall be equipped with a transversely oscillating screed or an extrusion plate to shape, compact, and smooth the surface and shall so finish the surface that no significant amount of hand finishing, except use of cutting straightedges, is required. The screed or extrusion plate shall be constructed to provide adjustment for crown in the pavement. The entire machine shall provide adjustment for variation in lane width or thickness and to prevent more than 200 mm 8 inches of the screed or extrusion plate extending over previously placed concrete on either end when paving fill-in lanes. Machines that cause displacement of properly installed forms or cause ruts or indentations in the prepared underlying materials and machines that cause frequent delays due to mechanical failures shall be replaced as directed.

d. Fixed Forms: The paver-finisher shall be equipped with wheels designed to ride the forms, keep it aligned with the forms, and spread the load so as to prevent deformation of the forms. Paver-finishers traveling on guide rails located outside the paving lane shall be equipped with wheels when traveling on new or existing concrete to remain.

e. Slipform: The slipform paver-finisher shall be automatically controlled and crawler mounted with padded tracks so as to be completely stable under all operating conditions. The paver-finisher shall finish the surface and edges so that no edge slump beyond allowable tolerance occurs. Suitable moving side forms shall be provided that are adjustable and will produce smooth, even edges, perpendicular to the top surface and meeting specification requirements for alignment and freedom from edge slump.

f. Longitudinal Mechanical Float: A longitudinal mechanical float shall be specially designed and manufactured to smooth and finish the pavement surface without working excess paste to the surface. It shall be rigidly attached to the rear of the paver-finisher or to a separate self-propelled frame spanning the paving lane. The float plate shall be at least 1.5 m 5 feet long by 200 mm 8 inches wide and shall automatically be oscillated in the longitudinal direction while slowly moving from edge to edge of the paving lane, with the float plate in contact with the surface at all times.

g. Nonrotating Pipe Float: A pipe float if used, shall be a nonrotating pipe 150 to 250 mm 6 to 10 inches in diameter and

sufficiently long to span the full paving width when oriented at an angle of approximately 60 degrees with the centerline. The pipe float shall be mounted on a self-propelled frame that spans the paving lane. No means of applying water to the surface shall be incorporated in the pipe float.

h. Other Types of Finishing Equipment: Clary screeds, other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd-shaped slabs, and near buildings or trench drains, subject to the Contracting Officer's approval. Bridge deck finishers shall have a minimum operating weight of 3400 kg 7500 pounds and shall have a transversely operating carriage containing a knock-down auger and a minimum of two immersion vibrators. Vibrating screeds or pans shall be used only for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

2.10.6 Curing Equipment

Equipment for applying membrane-forming curing compound shall be mounted on a self-propelled frame that spans the paving lane. The reservoir for curing compound shall be constantly mechanically (not air) agitated during operation and shall contain means for completely draining the reservoir. The spraying system shall consist of a mechanically powered pump which will maintain constant pressure during operation, an operable pressure gauge, and either a series of spray nozzles evenly spaced across the lane to give uniformly overlapping coverage or a single spray nozzle which is mounted on a carriage which automatically traverses the lane width at a speed correlated with the forward movement of the overall frame. All spray nozzles shall be protected with wind screens. Calibrate the spraying system in accordance with ASTM D2995, Method A, for the rate of application required in paragraph: Membrane Curing. Any hand-operated sprayers allowed by that paragraph shall be compressed air supplied by a mechanical air compressor. If the curing equipment fails to apply an even coating of compound at the specified rate, it shall immediately be replaced.

2.10.7 Texturing Equipment

****

NOTE: Designer must select type of texturing desired, retain that subparagraph, and delete the others. A genuine effort should be made to determine the type of texturing, if any, desired by the using service. If no guidance is given, the usual default method should be burlap drag. Edit bracketed phrases as appropriate. For Air Force airfield paving projects, do not specify artificial turf, wire comb, or surface grooving textures. Use Section 32 01 26.71 GROOVING FOR AIRFIELD PAVEMENTS, to specify saw-cut grooves. If other than a burlap drag textured finish is required, add the appropriate paragraph(s) as shown below. Spring tine grooving is limited to use on roads and streets only.

****

a. General: Texturing equipment shall be as specified below. Before use, the texturing equipment shall be demonstrated on a test section, and the equipment shall be modified as necessary to produce the texture

directed.

b. Burlap Drag: A burlap drag shall be securely attached to a separate wheel mounted frame spanning the paving lane or to one of the other similar pieces of equipment. Length of the material shall provide 600 to 900 mm 24 to 36 inches dragging flat on the pavement surface. Width shall be at least equal to the width of the slab. The material shall be clean, reasonably new burlap, completely saturated with water before attachment to the frame, always resaturated before start of use, and kept clean and saturated during use. Burlap shall conform to AASHTO M 182, Class 3 or 4.

c. Broom: Surface texture shall be applied using an approved mechanical stiff bristle broom drag of a type that will uniformly score the surface transverse to the pavement center line. The broom shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. The scores shall be uniform in appearance and approximately 1.5 mm 1/16 inch in depth but not more than 3 mm 1/8 inch in depth.

d. Artificial Turf: The artificial turf drag shall be full-width and the leading transverse edge shall be securely fastened to a lightweight pole on a traveling bridge. At least 600 mm 2 feet of the artificial turf shall be in contact with the concrete surface during texturing operations. The corrugations shall be uniform in appearance and approximately 2 mm 1/16 inch in depth. A variety of different types of artificial turf are available and approval of any one type will be done only after it has been demonstrated by the Contractor to provide a satisfactory texture. One type that has provided satisfactory texture consists of 7,200 approximately 0.85-inches-long polyethylene turf blades per square foot.

e. Deep Texturing Equipment: Texturing equipment shall consist of [a stiff bristled broom] [a comb with spring wire tines] [spring strips which will produce true, even grooves] forming a drag at least 1.2 m 4 feet long. This drag shall be mounted in a wheeled frame spanning the paving lane and so constructed that the drag is mechanically pulled in a straight line across the paving lane perpendicular to the centerline.

2.10.8 Sawing Equipment

****
NOTE: Retain bracketed sentence as necessary to correlate with paragraph Removal of Existing Pavement Slab in PART 3. Otherwise delete. Also delete wheel saw option on Navy projects.
****

Equipment for sawing joints and for other similar sawing of concrete shall be standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Blades shall be diamond tipped. If demonstrated to operate properly, abrasive blades may be used. Provide spares as required to maintain the required sawing rate. [Wheel saws used in the removal of concrete shall be saws with large diameter tungsten carbide tipped blades mounted on a heavy-duty chassis which will produce a saw kerf at least 40 mm 1-1/2 inch wide.] All saws shall be capable of sawing to the full depth required. Early-entry saws may be used, subject to demonstration and approval of the Contracting Officer. No change to the initial sawcut depth shall be permitted.

2.10.9 Straightedge

Furnish and maintain at the job site, in good condition, one 4 m 12 foot straightedge for each paving train for testing the hardened portland cement concrete surfaces. These straightedges shall be constructed of aluminum or magnesium alloy and shall have blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Straightedges shall have handles for operation on the pavement.

2.11 SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES

****
NOTE: Fill in blanks as appropriate. Specified strength must be the flexural strength used in the structural design of the pavement and should not exceed 650 psi (4.5 MPa) at 90 days of age. Designer must also ensure that this strength is attainable with the available aggregates. Air content should be specified as 6 percent where freezing and thawing is a concern and 4 percent where it is not a concern. Specify strength at 90 days. However, modify to 28-days in line 2 if 28-day strength is used in paragraphs: Flexural Strength and Thickness. Be sure this and succeeding paragraphs correlate.
****

2.11.1 Specified Flexural Strength

****
NOTE: Use the Tailoring Option "Beams" or "Cylinders/Beams" to specify flexural strength for concrete.
****

Specified flexural strength, R, for concrete is [_____] MPa psi at [28] [90] days, as determined by tests made in accordance with ASTM C78/C78M of beams fabricated and cured in accordance with ASTM C192/C192M, as determined by equivalent flexural strength, as specified in paragraph: Mixture Proportioning for Flexural Strength below. Maximum allowable water-cementitious material ratio is 0.45. The water-cementitious material ratio will be the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement plus SCM by the mass equivalency method described in ACI 211.1. The concrete shall be air-entrained with a total air content of [_____] plus or minus 1.5 percentage points, at the point of placement. Air content shall be determined in accordance with ASTM C231/C231M. The maximum allowable slump of the concrete at the point of placement shall be 50 mm 2 inches for pavement constructed with fixed forms. For slipformed pavement, at the start of the project, select a maximum allowable slump which will produce in-place pavement meeting the specified tolerances for control of edge slump. The selected slump shall be applicable to both pilot and fill-in lanes.

2.11.2 Concrete Temperature

The temperature of the concrete as delivered shall conform to the requirements of paragraphs, Paving in Hot Weather and Paving in Cold Weather, in PART 3. Temperature of concrete shall be determined in

accordance with ASTM C1064/C1064M.

2.11.3 Concrete Strength for Final Acceptance

****
NOTE: Use the Tailoring Option to specify concrete strength by using "Cylinders/Beams" or "Beams".
****

The strength of the concrete will be considered acceptable when the average equivalent [90-day] [28-day] flexural strengths for each lot are above the 'Specified Flexural Strength' as determined by correlation with 14-day compressive strength tests specified in paragraph: "Mixture Proportioning for Flexural Strength" below, The strength of the concrete will be considered acceptable when the equivalent [90-day] [28-day] flexural strengths for each lot are above the'Specified Flexural Strength' as determined by correlation with 14-day flexural strength tests specified in paragraph: "Mixture Proportioning for Flexural Strength" below, and no individual set (2 specimens per sublot) in the lot are 170 kPa 25 psi or more below the equivalent 'Specified Flexural Strength'. If any lot or sublot, respectively, fails to meet the above criteria, the lot or sublot shall be removed and replaced at no additional cost to the Government. This is in addition to and does not replace the average strength required for day-to-day CQC operations as specified in paragraph: Average CQC Flexural Strength Required for Mixtures, below.

2.12 MIXTURE PROPORTIONS

****
NOTE: Edit bracketed items as appropriate. Normally, permit accelerator only with fast-track paving. If approval has been obtained and airfield pavement has been designed and specified for 28-day flexural strength in paragraph: Specified Flexural Strength, modify the following subparagraphs accordingly. Do the same if this is road pavement designed for 28-day strength. Use the higher bracketed cement content if pozzolan is used.
****

2.12.1 Composition

Concrete shall be composed of cementitious material, water, fine and coarse aggregates, and admixtures. Supplementary Cementitious Materials (SCM) choice and usage shall be in accordance with paragraph: Supplementary Cementitious Materials (SCM) Content. The total cementitious material content shall be at least [280 kg/cubic meter 470 lb./cu. yd.] [310 kg/cubic meter 517 lb./cu. yd.]. Admixtures shall consist of air entraining admixture and may also include, as approved, [accelerator] [retarder] [water-reducing admixture].

2.12.2 Proportioning Studies

Trial design batches, mixture proportioning studies, and testing requirements are the responsibility of the Contractor. Submit the results of the mixture proportioning studies signed and stamped by the registered professional engineer having technical responsibility for the mix design study, and submitted at least 30 days prior to commencing concrete placing operations. The results shall include a statement giving the maximum

nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic meter yard basis. Aggregate quantities shall be based on the mass in a saturated surface dry condition. The recommended mixture proportions shall be accompanied by test results demonstrating that the proportions selected will produce concrete of the qualities indicated. Trial mixtures having proportions, slumps, and air content suitable for the work shall be based on methodology described in ACI 211.1, modified as necessary to accommodate flexural strength. Submit test results including:

a. Coarse and fine aggregate gradations and plots.
b. Combined aggregate gradation [and coarseness/workability] plots.
c. Coarse aggregate quality test results, include deleterious materials.
d. Fine aggregate quality test results.
e. Mill certificates for cement and supplemental cementitious materials.
f. Certified test results for air entraining, water reducing, retarding, non-chloride accelerating[, and Lithium Nitrate] admixtures.
g. Specified flexural strength, slump, and air content.
h. Documentation of required average CQC flexural strength, Ra.
i. Recommended proportions/volumes for proposed mixture and each of three trial water-cementitious materials ratios.
j. Individual beam [and cylinder] breaks.
k. Flexural [and compressive]strength summaries and plots.
l. Correlation ratios for acceptance testing and CQC testing.
m. Historical record of test results, documenting production standard deviation (if available).

2.12.2.1 Water-Cement Ratio

At least three different water-cement ratios, which will produce a range of strength encompassing that required on the project, shall be used. The maximum allowable water-cement ratio required in paragraph: Specified Flexural Strength, above will be the equivalent water-cement ratio. Laboratory trial mixtures shall be proportioned for maximum permitted slump and air content.

2.12.2.2 Trial Mixture Studies

Separate sets of trial mixture studies shall be made for each combination of cementitious materials and each combination of admixtures proposed for use. No combination of either shall be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerator or a retarder may be used without separate trial mixture study. Separate trial mixture studies shall also be made for concrete for each placing method (slip form, fixed form, or hand placement) proposed. The temperature of concrete in each trial batch shall be reported. Each mixture shall be designed to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.

2.12.2.3 Mixture Proportioning for Flexural Strength

****
NOTE: The first Tailoring Option, "Beams", includes items a through j; the second option "Cylinders/Beams" includes the second listing of items 1 through 10.
****

The following step by step procedure shall be followed:

a. Fabricate all beams for each mixture from the same batch or blend of batches. Fabricate and cure all beams in accordance with ASTM C192/C192M, using 152 x 152 mm 6 x 6 inch steel beam forms.

b. Cure test beams from each mixture for 3, 7, 14, and [28] [90]-day flexural tests; 6 beams to be tested per age.

c. Test beams in accordance with ASTM C78/C78M.

d. Using the average strength for each w/c at each age, plot all results from each of the three mixtures on separate graphs for w/c versus:
3-day flexural strength
7-day flexural strength
14-day flexural strength
[28-day flexural strength]
[90-day flexural strength]

e. From these graphs select a w/c that will produce a mixture giving a [28] [90]-day flexural strength equal to the required strength determined in accordance with the next paragraph.

f. Using the above selected w/c, select from the graphs the expected 3, 7 and 14-day flexural strengths.

g. From the above expected strengths for the selected mixture, determine the Ratio of the 7-day flexural strength of the selected mixture to the [28] [90]-day flexural strength of the mixture (for CQC control).

h. From the above expected strengths for the selected mixture, determine the Ratio of the 14-day flexural strength of the selected mixture to the [28] [90]-day flexural strength of the mixture (for acceptance).

i. If there is a change in materials, additional mixture design studies shall be made using the new materials and new Correlation Ratios shall be determined.

j. No concrete pavement shall be placed until the Contracting Officer has approved the Contractor's mixture proportions. The approved water-cementitious materials ratio shall not exceed the maximum value specified in paragraph: Specified Flexural Strength, above and shall not be increased without the Contracting Officer's written approval.

1 . Fabricate all beams and cylinders for each mixture from the same batch or blend of batches. Fabricate and cure all beams and cylinders in accordance with ASTM C192/C192M, using 152 x 152 mm 6 x 6 inch steel beam forms and 152 x 305 mm 6 x 12 inch single-use cylinder forms.

2. Cure test beams from each mixture for 3, 7, 14, [28] and [90]-day flexural tests; 6 beams to be tested per age.

3. Cure test cylinders from each mixture for 3, 7, 14, [28] and [90]-day compressive strength tests; 6 cylinders to be tested per age.

4. Test beams in accordance with ASTM C78/C78M, cylinders in

accordance with ASTM C39/C39M.

5. Using the average strength for each w/c at each age, plot all results from each of the three mixtures on separate graphs for w/c versus:

3-day flexural strength
7-day flexural strength
14-day flexural strength
[28-day flexural strength]
[90-day flexural strength]

3-day compressive strength
7-day compressive strength
14-day compressive strength
[28-day compressive strength]
[90-day compressive strength]

6. From these graphs select a w/c that will produce a mixture giving a [28] [90]-day flexural strength equal to the required strength determined in accordance with the next paragraph.

7. Using the above selected w/c, select from the graphs the expected 3, 7, 14, [28] [90]-day flexural strengths and the expected 3, 7, 14, [28] [90]-day compressive strengths for the mixture.

8. From the above expected strengths for the selected mixture determine the following Correlation Ratios:

(1) Ratio of the 14-day compressive strength of the selected mixture to the [28] [90]-day flexural strength of the mixture (for acceptance).

(2) Ratio of the 7-day compressive strength of the selected mixture to the [28] [90]-day flexural strength of the mixture (for CQC control).

9. If there is a change in materials, additional mixture design studies shall be made using the new materials and new Correlation Ratios shall be determined.

10. No concrete pavement shall be placed until the Contracting Officer has approved the Contractor's mixture proportions. The approved water-cementitious materials ratio shall not exceed the maximum value specified in the next paragraph and shall not be increased without the Contracting Officer's written approval.

2.12.3 Average CQC Flexural Strength Required for Mixtures

In order to ensure meeting the strength requirements specified in paragraph: SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES above, during production, the mixture proportions selected during mixture proportioning studies and used during construction shall produce a required average CQC flexural strength exceeding the specified strength, R, by the amount indicated below. This required average CQC flexural strength, Ra, will be used only for CQC operations as specified in paragraph: TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3 and as specified in the previous paragraph. During production, the required Ra shall be adjusted , as appropriate and as approved, based on the standard deviation of equivalent [28] [90] average [28] [90]-day strengths being attained during

paving.

a. From Previous Test Records: Where a concrete production facility has previous test records current to within 18 months, a standard deviation shall be established in accordance with the applicable provisions of ACI 214R. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected, shall represent concrete produced to meet a specified flexural strength or strengths within 1 MPa 150 psi of the [28] [90]-day flexural strength specified for the proposed work, and shall consist of at least 30 consecutive tests. Perform verification testing, as directed by the Contracting Officer, to document the current strength. A strength test shall be the average of the strengths of two specimens made from the same sample of concrete and tested at [28] [90] days. Required average CQC flexural strength, Ra, used as the basis for selection of concrete proportions shall be the value from the equation that follows, using the standard deviation as determined above:

Ra = R + 1.34S

Where: S = standard deviation
R = specified flexural strength
Ra = required average flexural strength

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS	MODIFICATION FACTOR FOR STANDARD DEVIATION
15	1.16
20	1.08
25	1.03
30 or more	1.00

b. Without Previous Test Records: When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength, Ra, shall be determined by adding 15 percent to the specified flexural strength, R.

PART 3 EXECUTION

3.1 PREPARATION FOR PAVING

Before commencing paving, perform the following. If used, forms shall be in place, cleaned, coated, and adequately supported. Any reinforcing steel needed shall be at the paving site. All transporting and transfer equipment shall be ready for use, clean, and free of hardened concrete and foreign material. Equipment for spreading, consolidating, screeding, finishing, and texturing concrete shall be at the paving site, clean and in proper working order. All equipment and material for curing and for protecting concrete from weather or mechanical damage shall be at the paving site, in proper working condition, and in sufficient amount for the entire placement.

3.1.1 Weather Prevention

When windy conditions during paving appear probable, equipment and material shall be at the paving site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.2 Proposed Techniques

****
NOTE: Include joint layout and typical detail of joint/dowel bar spacing in drawings and coordinate with paragraph: Placing Dowels and Tie Bars. Insert office title for approval of joint plan changes.
****

Submit placing and protection methods; paving sequence; jointing pattern; data on curing equipment and profilographs; demolition of existing pavements, as specified; pavement diamond grinding equipment and procedures. Submit for approval the following items:

a. A description of the placing and protection methods proposed when concrete is to be placed in or exposed to hot, cold, or rainy weather conditions.

b. A detailed paving sequence plan and proposed paving pattern showing all planned construction joints; transverse and longitudinal dowel bar spacing; and identifying pilot lanes and hand placement areas. No deviation from the jointing pattern shown on the drawings shall be made without written approval of the [design engineer] [_____].

c. Plan and equipment proposed to control alignment of sawn joints within the specified tolerances.

d. Data on the curing equipment, media and methods to be used.

e. Data on profilograph and methods to measure pavement smoothness.

f. Pavement demolition work plan, presenting the proposed methods and equipment to remove existing pavement and protect pavement to remain in place.

3.2 CONDITIONING OF UNDERLYING MATERIAL

3.2.1 General Procedures

Underlying material, upon which concrete is to be placed shall be clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. Prior to setting forms or placement of concrete, the underlying material shall be well drained and shall have been satisfactorily graded by string-line controlled, automated, trimmer/fine grader and uniformly compacted in accordance with the applicable Section of these specifications. The surface of the underlying material shall be tested as to crown, elevation, and density in advance of setting forms or of concrete placement using slip-form techniques. High areas shall be trimmed to proper elevation. Low areas shall be filled and compacted to a

condition similar to that of surrounding grade, or filled with concrete monolithically with the pavement. Low areas filled with concrete shall not be cored for thickness to avoid biasing the average thickness used for evaluation and payment adjustment. Any underlying material disturbed by construction operations shall be reworked and recompacted to specified density immediately in front of the paver. If a slipform paver is used, the same underlying material under the paving lane shall be continued beyond the edge of the lane a sufficient distance and shall be thoroughly compacted and true to grade to provide a suitable trackline for the slipform paver and firm support for the edge of the paving lane.

3.2.2 Traffic on Underlying Material

****
NOTE: Transporting equipment should not be allowed to operate on the prepared underlying material for airfield paving. Operating hauling equipment in the paving lane will cause the paver to stop frequently, producing a discontinuity in the pavement surface. Edit bracketed items as appropriate and coordinate with Part 2, subparagraph: Transfer and Spreading Equipment.
****

After the underlying material has been prepared for concrete placement, no equipment shall be permitted thereon. Subject to specific approval, crossing of the prepared underlying material at specified intervals for construction purposes may be permitted, provided rutting or indentations do not occur. The surface shall be reworked and reprepared to the satisfaction of the Contracting Officer before concrete is placed. [No transporting equipment shall be allowed to operate on the prepared and compacted underlying material in front of the paver-finisher.] [Equipment shall be allowed to operate on the underlying material only if approved by the Contracting Officer and only if no damage is done to the underlying material and its degree of compaction. Any disturbance to the underlying material that does occur shall be corrected, as approved, before the paver-finisher or the deposited concrete reaches the location of the disturbance and the equipment shall be replaced or procedures changed to prevent any future damage.]

3.3 WEATHER LIMITATIONS

3.3.1 Placement and Protection During Inclement Weather

Do not commence placing operations when heavy rain or other damaging weather conditions appear imminent. At all times when placing concrete, maintain on-site sufficient waterproof cover and means to rapidly place it over all unhardened concrete or concrete that might be damaged by rain. Suspend placement of concrete whenever rain, high winds, or other damaging weather commences to damage the surface or texture of the placed unhardened concrete, washes cement out of the concrete, or changes the water content of the surface concrete. All unhardened concrete shall be immediately covered and protected from the rain or other damaging weather. Any slab damaged by rain or other weather shall be completely removed full depth, by full slab width, to the nearest original joint, and replaced at the Contractor's expense as specified in paragraph: REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS below.

3.3.2 Paving in Hot Weather

****
NOTE: Additional information concerning hot weather concreting may be obtained from ACI 305R. Do not delete this paragraph or the next paragraphs dealing with weather.
****

When the ambient temperature during paving is expected to exceed 32 degrees C 90 degrees F, the concrete shall be properly placed and finished in accordance with procedures previously submitted, approved, and as specified herein. The concrete temperature at time of delivery to the forms shall not exceed the temperature shown in the table below when measured in accordance with ASTM C1064/C1064M. Cooling of the mixing water or aggregates or placing in the cooler part of the day may be required to obtain an adequate placing temperature. Steel forms and reinforcing shall be cooled as needed to maintain steel temperatures below 49 degrees C 120 degrees F. Transporting and placing equipment shall be cooled or protected if necessary to maintain proper concrete placing temperature. The finished surfaces of the newly laid pavement shall be kept damp by applying a fog spray (mist) with approved spraying equipment until the pavement is covered by the curing medium.

Maximum Allowable Concrete Placing Temperature

Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature in Degrees C
Greater than 60	33
40-60	30
Less than 40	27

Maximum Allowable Concrete Placing Temperature

Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature in Degrees F
Greater than 60	90
40-60	85
Less than 40	80

3.3.3 Prevention of Plastic Shrinkage Cracking

During weather with low humidity, and particularly with high temperature and appreciable wind, develop and institute measures to prevent plastic shrinkage cracks from developing. If plastic shrinkage cracking occurs, halt further placement of concrete until protective measures are in place to prevent further cracking. Periods of high potential for plastic shrinkage cracking can be anticipated by use of Fig. 2.1.5 of ACI 305R. In addition to the protective measures specified in the previous paragraph, the concrete placement shall be further protected by erecting shades and windbreaks and by applying fog sprays of water, the addition of monomolecular films, or wet covering. When such water treatment is stopped, curing procedures shall be immediately commenced. Plastic shrinkage cracks that occur shall be repaired in accordance with paragraph: REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Plastic shrinkage

cracks shall never be troweled over or filled with slurry.

3.3.4 Paving in Cold Weather

Cold weather paving shall conform to ACI 306R. Special protection measures, as specified herein, shall be used if freezing temperatures are anticipated before the expiration of the specified curing period. Placement of concrete shall not begin unless the ambient temperature is at least 2 degrees C 35 degrees F and rising. Thereafter, placement of concrete shall be halted whenever the ambient temperature drops below 5 degrees C 40 degrees F. When the ambient temperature is less than 10 degrees C 50 degrees F, the temperature of the concrete when placed shall be not less than 10 degrees C 50 degrees F nor more than 25 degrees C 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. If allowed under paragraph: MIXTURE PROPORTIONS in PART 2, an accelerating admixture may be used when the ambient temperature is below 10 degrees C 50 degrees F. Covering and other means shall be provided for maintaining the concrete at a temperature of at least 10 degrees C 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period. Pavement slabs damaged by freezing shall be removed full depth, by full slab width, to the nearest original joint, and replaced at the Contractor's expense as specified in paragraph: REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS.

3.4 CONCRETE PRODUCTION

****
NOTE: Designer must correlate these paragraphs with paragraph EQUIPMENT. Delete item in brackets if truck mixers are not permitted.
****

Batching, mixing, and transporting equipment shall have a capacity sufficient to maintain a continuous, uniform forward movement of the paver of not less than 0.8 m 2.5 feet per minute. Concrete transported in non-agitating equipment shall be deposited in front of the paver within 45 minutes from the time cement has been charged into the mixing drum, except that if the ambient temperature is above 32 degrees C 90 degrees F, the time shall be reduced to 30 minutes. Concrete transported in truck mixers shall be deposited in front of the paver within 90 minutes from the time cement has been charged into the mixer drum of the plant or truck mixer. If the ambient temperature is above 32 degrees C 90 degrees F, the time shall be reduced to 60 minutes. Every load of concrete delivered to the paving site shall be accompanied by a batch ticket from the operator of the batching plant. Tickets shall be on approved forms and shall show at least the mass, or volume, of all ingredients in each batch delivered, [the water meter and revolution meter reading on truck mixers] and the time of day. Tickets shall be delivered to the placing foreman who shall keep them on file and deliver them to the Government weekly, or as directed by the Contracting Officer.

3.4.1 Batching and Mixing Concrete

Scale pivots and bearings shall be kept clean and free of rust. Any equipment which fails to perform as specified shall immediately be removed from use until properly repaired and adjusted, or replaced.

3.4.2 Transporting and Transfer - Spreading Operations

Non-agitating equipment shall be used only on smooth roads and for haul time less than 15 minutes. Concrete shall be deposited as close as possible to its final position in the paving lane. All equipment shall be operated to discharge and transfer concrete without segregation. In no case shall dumping of concrete in discrete piles be permitted. No transfer or spreading operation which requires the use of front-end loaders, dozers, or similar equipment to distribute the concrete will be permitted.

3.5 PAVING

****
NOTE: Designer must correlate these paragraphs with paragraph EQUIPMENT.
****

3.5.1 General Requirements

Pavement shall be constructed with paving and finishing equipment utilizing rigid fixed forms or by use of slipform paving equipment. Paving and finishing equipment and procedures shall be capable of constructing paving lanes of the required width at a rate of at least 30 m 100 feet of paving lane per hour on a routine basis. Paving equipment and its operation shall be controlled, and coordinated with all other operations, such that the paver-finisher has a continuous forward movement, at a reasonably uniform speed, from beginning to end of each paving lane, except for inadvertent equipment breakdown. Failure to achieve this shall require the Contractor to halt operations, regroup, and modify operations to achieve this requirement. Workmen with foreign material on their footwear or construction equipment that might deposit foreign material shall not be permitted to walk or operate in the plastic concrete. Where an open-graded granular base is required under the concrete, select paving equipment and procedures which will operate properly on the base course without causing displacement or other damage.

3.5.2 Consolidation

Concrete shall be consolidated with the specified type of lane-spanning, gang-mounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand-operated vibrators. The vibrators shall be inserted into the concrete to a depth that will provide the best full-depth consolidation but not closer to the underlying material than 50 mm 2 inches. Excessive vibration shall not be permitted. If the vibrators cause visible tracking in the paving lane, the paving operation shall be stopped and equipment and operations modified to prevent it. Concrete in small, odd-shaped slabs or in isolated locations inaccessible to the gang-mounted vibration equipment shall be vibrated with an approved hand-operated immersion vibrator operated from a bridge spanning the area. Vibrators shall not be used to transport or spread the concrete. Hand-operated vibrators shall not be operated in the concrete at one location for more than 20 seconds. Insertion locations for hand-operated vibrators shall be between 150 to 400 mm 6 to 15 inches on centers. For each paving train, at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators shall be maintained at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) shall require the immediate stopping of

the paving operation and approved adjustment of the equipment or procedures.

3.5.3 Operation

When the paver approaches a header at the end of a paving lane, a sufficient amount of concrete shall be maintained ahead of the paver to provide a roll of concrete which will spill over the header. The amount of extra concrete shall be sufficient to prevent any slurry that is formed and carried along ahead of the paver from being deposited adjacent to the header. The spud vibrators in front of the paver shall be brought as close to the header as possible before they are lifted. Additional consolidation shall be provided adjacent to the headers by hand-manipulated vibrators. When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provisions shall be made to prevent damage to the previously constructed pavement. Screeds or extrusion plates shall be electronically controlled from the previously placed pavement so as to prevent them from applying pressure to the existing pavement and to prevent abrasion of the pavement surface. The overlapping area of existing pavement surface shall at all times be kept completely free of any loose or bonded foreign material as the paver-finisher operates across it. When the paver travels on existing pavement, approved provisions shall be made to prevent damage to the existing pavement. Pavers using transversely oscillating screeds shall not be used to form fill-in lanes that have widths less than a full width for which the paver was designed or adjusted.

3.5.4 Required Results

The paver-finisher, and its gang-mounted vibrators, together with its operating procedures shall be adjusted and operated and coordinated with the concrete mixture being used to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. The paver-finishing operation shall produce a surface finish free of irregularities, tears, voids of any kind, and any other discontinuities. The paver-finisher shall make only one pass across the pavement; multiple passes will not be permitted. The equipment and its operation shall produce a finished surface requiring no hand finishing other than the use of cutting straightedges, except in very infrequent instances. If any equipment or operation fails to produce the above results, the paving shall be stopped, the equipment shall be replaced or properly adjusted, the operation shall be appropriately modified, or the mixture proportions modified, in order to produce the required results before recommencing paving. No water, other than fog sprays (mist) as specified in paragraph: Prevention of Plastic Shrinkage Cracking above, shall be applied to the concrete or the concrete surface during paving and finishing.

3.5.5 Fixed Form Paving

****
NOTE: Fixed-form paving should always be included as an option or mandatory item as appropriate. Edit bracketed items in subparagraph a. Keys are only permitted for roads and streets with a thickness of 230 mm (9 inches) or greater. Do not permit keys for airfield pavements.
****

Paving equipment for fixed-form paving and the operation thereof shall conform to the requirements of paragraph EQUIPMENT, and all requirements specified herein.

3.5.5.1 Forms for Fixed-Form Paving

****
NOTE: Delete subparagraph e. when overlay pavements are not required.
****

a. Straight forms shall be made of steel and shall be furnished in sections not less than 3 m 10 feet in length. Flexible or curved forms of proper radius shall be used for curves of 31 m 100-foot radius or less. Wood forms for curves and fillets shall be made of well-seasoned, surfaced plank or plywood, straight, and free from warp or bend. Wood forms shall be adequate in strength and rigidly braced. Forms shall have a depth equal to the pavement thickness at the edge. Where the project requires several different slab thicknesses, forms may be built up by bolting or welding a tubular metal section or by bolting wood planks to the bottom of the form to completely cover the underside of the base of the form and provide an increase in depth of not more than 25 percent. The base width of the one-piece or built-up form shall be not less than eight-tenths of the vertical height of the form, except than forms 200 mm 8 inches or less in vertical height shall have a base width not less than the vertical height of the form. Maximum vertical deviation of top of any side form, including joints, shall not vary from a true plane more than 3 mm 1/8 inch in 3 m 10 feet, and the upstanding leg shall not vary more than 6 mm 1/4 inch. [Where keyway forms are required, they shall be rigidly attached to the main form so no displacement can take place. Metal keyway forms shall be tack-welded to steel forms. Keyway forms shall be so aligned that there is no variation over 6 mm 1/4 inch either vertically or horizontally, when tested with a 4 m 12 foot template after forms are set, including tests across form joints.]

b. Form sections shall be tightly locked and shall be free from play or movement in any direction. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment.

c. Set forms for full bearing on foundation for entire length and width and in alignment with edge of finished pavement. Support forms during entire operation of placing, compaction, and finishing so that forms will not deviate vertically more than 3 mm 0.01 foot from required grade and elevations indicated. Conformity to the alignment and grade elevations shown on the drawings shall be checked and necessary corrections shall be made immediately prior to placing the concrete. The forms shall be cleaned and oiled each time before concrete is placed. No concrete shall be placed until setting of forms has been checked and approved by the CQC team.

d. Do not anchor guide rails for fixed form pavers into new concrete or existing concrete to remain.

e. Forms for overlay pavements and for other locations where forms must be set on existing pavements shall be held securely in place with stakes or by other approved methods. Holes in existing pavements for form stakes shall be carefully drilled by methods which will not crack or spall the existing pavement. After use, the holes shall be filled flush with the surrounding surface using approved material, prior to

overlying materials being placed. Any method which does not hold the form securely or which damages the existing pavement shall be immediately discontinued. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location without proceeding further until the proposed method is approved by the Contracting Officer.

3.5.5.2 Form Removal

Keep forms in place at least 12 hours after the concrete has been placed. When conditions are such that the early strength gain of the concrete is delayed, leave the forms in place for a longer time, as directed. Remove forms by procedures that do not injure the concrete. Bars or heavy metal tools shall not be used directly against the concrete in removing the forms. Any concrete found to be defective after form removal shall be repaired promptly, using procedures specified or as directed.

3.5.6 Slipform Paving

****
NOTE: Retain slipform paving as an option unless there are specific, valid reasons for deleting it. Be sure all other paragraphs correlate with choice made here.
****

3.5.6.1 General

Paving equipment for slipform paving and the operation thereof shall conform to the requirement of paragraph EQUIPMENT, and all requirements specified herein. The slipform paver shall shape the concrete to the specified and indicated cross section, meeting all tolerances, in one pass. The slipform paver shall finish the surface and edges so that only a very minimum isolated amount of hand finishing is required. If the paving operation does not meet the above requirements and the specified tolerances, immediately stop the operation, and regroup and replace or modify any equipment as necessary, modify paving procedures or modify the concrete mix, in order to resolve the problem. The slipform paver shall be automatically electronically controlled from a taut wire guideline for horizontal alignment and on both sides from a taut wire guideline for vertical alignment, except that electronic control from a ski operating on a previously constructed adjoining lane shall be used where applicable for either or both sides. Automatic, electronic controls for vertical alignment shall always be used on both sides of the lane. Control from a slope-adjustment control or control operating from the underlying material shall never be used. Side forms on slipform pavers shall be properly adjusted so that the finished edge of the paving lane meets all specified tolerances. Dowels in longitudinal construction joints shall be installed as specified below. The installation of these dowels by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete shall not be permitted. [If a keyway is required, a 0.45 to 0.55 mm 26 gauge thick metal keyway liner shall be installed as the keyway is extruded. Keyway forms shall not vary more than plus or minus 3 mm 1/8 inch from the dimensions indicated and shall not deviate more than plus or minus 6 mm 1/4 inch from the mid-depth of the pavement. There shall be no abrupt offset either horizontally or vertically in the completed keyway. The keyway liner shall be protected and shall remain in place and become part of the joint.]

3.5.6.2 Guideline for Slipform Paving

Accurately and securely install guidelines well in advance of concrete placement. Provide supports at necessary intervals to eliminate all sag in the guideline when properly tightened. The guideline shall be high strength wire set with sufficient tension to remove all sag between supports. Supports shall be securely staked to the underlying material or other provisions made to ensure that the supports will not be displaced when the guideline is tightened or when the guideline or supports are accidentally touched by workmen or equipment during construction. The appliances for attaching the guideline to the supports shall be capable of easy adjustment in both the horizontal and vertical directions. When it is necessary to leave gaps in the guideline to permit equipment to use or cross underlying material, provisions shall be made for quickly and accurately replacing the guideline without any delay to the forward progress of the paver. Supports on either side of the gap shall be secured in such a manner as to avoid disturbing the remainder of the guideline when the portion across the gap is positioned and tightened. The guideline across the gap and adjacent to the gap for a distance of 60 m 200 feet shall be checked for horizontal and vertical alignment after the guideline across the gap is tightened. Vertical and horizontal positioning of the guideline shall be such that the finished pavement shall conform to the alignment and grade elevations shown on the drawings within the specified tolerances for grade and smoothness. The specified tolerances are intended to cover only the normal deviations in the finished pavement that may occur under good supervision and do not apply to setting of the guideline. The guideline shall be set true to line and grade.

3.5.6.3 Laser Controls

If the Contractor proposes to use any type of automatic laser controls, submit a detailed description of the system and perform a trial field demonstration in the presence of the Contracting Officer at least one week prior to start of paving. Approval of the control system will be based on the results of the demonstration and on continuing satisfactory operation during paving.

3.5.7 Placing Reinforcing Steel

****
NOTE: Delete bracketed item if CRCP is not being constructed.
****

The type and amount of steel reinforcement shall be as shown on the drawings.

3.5.7.1 Pavement Thickness Greater Than 300 mm 12 Inches

For pavement thickness of 300 mm 12 inches or more, the reinforcement steel shall be installed by the strike-off method wherein a layer of concrete is deposited on the underlying material, consolidated, and struck to the indicated elevation of the steel reinforcement. The reinforcement shall be laid upon the prestruck surface, and the remaining concrete shall then be placed and finished in the required manner. When placement of the second lift causes the steel to be displaced horizontally from its original position, provisions shall be made for increasing the thickness of the first lift and depressing the reinforcement into the unhardened concrete to the required elevation. The increase in thickness shall be only as

necessary to permit correct horizontal alignment to be maintained. Any portions of the bottom layer of concrete that have been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with newly mixed concrete without additional cost to the Government.

3.5.7.2 Pavement Thickness Less Than 300 mm 12 Inches

For pavements less than 300 mm 12 inches thick, the reinforcement shall be positioned on suitable chairs or continuous mesh support devices securely fastened to the subgrade prior to concrete placement. Concrete shall be vibrated after the steel has been placed. Regardless of placement procedure, the reinforcing steel shall be free from coatings which could impair bond between the steel and concrete, and laps in the reinforcement shall be as indicated. Regardless of the equipment or procedures used for installing reinforcement, ensure that the entire depth of concrete is adequately consolidated. [If reinforcing for Continuously Reinforced Concrete Pavement (CRCP) is required, the entire operating procedure and equipment proposed shall be submitted for approval at least 30 days prior to proposed start of paving.]

3.5.8 Placing Dowels and Tie Bars

****
NOTE: Delete references to slipform paving installation of dowels and tie bars if slipform paving is not allowed. Delete references to installation in contraction joints if not required. Delete bracketed references to tie bars, if tie bars are not used.
****

The method used in installing and holding dowels in position shall ensure that the error in alignment of any dowel from its required horizontal and vertical alignment after the pavement has been completed will not be greater than 3 mm per 300 mm 1/8 in. per ft. Except as otherwise specified below, horizontal spacing of dowels shall be within a tolerance of plus or minus 15 mm 5/8 inch. The vertical location on the face of the slab shall be within a tolerance of plus or minus 13 mm1/2 inch). The vertical alignment of the dowels shall be measured parallel to the designated top surface of the pavement, except for those across the crown or other grade change joints. Dowels across crowns and other joints at grade changes shall be measured to a level surface. Horizontal alignment shall be checked perpendicular to the joint edge. The horizontal alignment shall be checked with a framing square. Dowels [and tie bars] shall not be placed closer than 0.6 times the dowel bar [tie bar] length to the planned joint line. If the last regularly spaced dowel [tie bar] is closer than that dimension, it shall be moved away from the joint to a location 0.6 times the dowel bar [tie bar] length, but not closer than 150 mm 6 inches to its nearest neighbor. Dowel (tie bar) interference at a transverse joint-longitudinal joint intersection shall be resolved by deleting the closest transverse dowel (tie bar). Dowels shall be installed as specified in the following subparagraphs.

3.5.8.1 Contraction Joints

Dowels [and tie bars] in longitudinal and transverse contraction joints within the paving lane shall be held securely in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. The

basket assemblies shall be held securely in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires. At the Contractor's option, in lieu of the above, dowels [and tie bars] in contraction joints shall be installed near the front of the paver by insertion into the plastic concrete using approved equipment and procedures. Approval will be based on the results of a preconstruction demonstration, showing that the dowels [and tie bars] are installed within specified tolerances.

3.5.8.2 Construction Joints-Fixed Form Paving

Installation of dowels [and tie bars] shall be by the bonded-in-place method. Installation by removing and replacing in preformed holes will not be permitted. Dowels [and tie bars] shall be prepared and placed across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms. The spacing of dowels [and tie bars] in construction joints shall be as indicated, except that, where the planned spacing cannot be maintained because of form length or interference with form braces, closer spacing with additional dowels [or tie bars] shall be used.

3.5.8.3 Dowels Installed in Hardened Concrete

****
NOTE: The first Tailoring Option is for "Cylinders/Beams" and the second option is for "Beams".
****

Install dowels in hardened concrete by bonding the dowels into holes drilled into the hardened concrete. The concrete shall have cured for 7 days or reached a minimum compressive strength of 17 MPa 2500 psi flexural strength of 3.1 MPa 450 psi before drilling commences. Holes 3 mm 1/8 inch greater in diameter than the dowels shall be drilled into the hardened concrete using rotary-core drills. Rotary-percussion drills may be used, provided that excessive spalling does not occur to the concrete joint face. Continuing damage shall require modification of the equipment and operation. Depth of dowel hole shall be within a tolerance of plus/minus 13 mm 1/2 inch of the dimension shown on the drawings. Upon completion of the drilling operation, the dowel hole shall be blown out with oil-free, compressed air. Dowels shall be bonded in the drilled holes using epoxy resin. Epoxy resin shall be injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel will not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic grout retention ring fitted around the dowel. Dowels required to be installed in any joints between new and existing concrete shall be grouted in holes drilled in the existing concrete, all as specified above. [Where tie bars are required in longitudinal construction joints of slipform pavement, bent tie bars shall be installed at the paver, in front of the transverse screed or extrusion plate. Tie bars shall not be installed in preformed holes. A standard keyway shall be constructed, and the bent tie bars shall be inserted into the plastic concrete through a 0.45 to 0.55 mm 26 gauge thick metal keyway liner. The keyway liner shall be protected and shall remain in place and become part of the joint. When bending tie bars, the radius of bend shall not be less than the minimum recommended for the particular grade of steel

in the appropriate material standard. Before placement of the adjoining paving lane, the tie bars shall be straightened, using procedures which will not spall the concrete around the bar.]

3.5.8.4 Lubricating Dowel Bars

The portion of each dowel intended to move within the concrete or expansion cap shall be wiped clean and coated with a thin, even film of lubricating oil or light grease before the concrete is placed.

3.6 FINISHING

****
NOTE: Edit bracketed items as appropriate. Retain slipform paving subparagraph except when it is prohibited elsewhere. Delete Other Types of Finishing Equipment here and in PART 2, if not wanted. Hand finishing is to be allowed only for isolated, small, odd-shaped slabs or places inaccessible to the paver.
****

Finishing operations shall be a continuing part of placing operations starting immediately behind the strike-off of the paver. Initial finishing shall be provided by the transverse screed or extrusion plate. The sequence of operations shall be transverse finishing, longitudinal machine floating if used, straightedge finishing, texturing, and then edging of joints. Finishing shall be by the machine method. The hand method shall be used only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Supplemental hand finishing for machine finished pavement shall be kept to an absolute minimum. Any machine finishing operation which requires appreciable hand finishing, other than a moderate amount of straightedge finishing, shall be immediately stopped and proper adjustments made or the equipment replaced. Any operations which produce more than 3 mm 1/8 inch of mortar-rich surface (defined as deficient in plus 4.75 mmU.S. No. 4 sieve size aggregate) shall be halted immediately and the equipment, mixture, or procedures modified as necessary. Compensation shall be made for surging behind the screeds or extrusion plate and settlement during hardening and care shall be taken to ensure that paving and finishing machines are properly adjusted so that the finished surface of the concrete (not just the cutting edges of the screeds) will be at the required line and grade. Finishing equipment and tools shall be maintained clean and in an approved condition. At no time shall water be added to the surface of the slab with the finishing equipment or tools, or in any other way, except for fog (mist) sprays specified to prevent plastic shrinkage cracking.

3.6.1 Machine Finishing With Fixed Forms

The machine shall be designed to ride the forms and shall be operated to screed and consolidate the concrete. Machines that cause displacement of the forms shall be replaced. The machine shall make only one pass over each area of pavement. If the equipment and procedures do not produce a surface of uniform texture, true to grade, in one pass, the operation shall be immediately stopped and the equipment, mixture, and procedures adjusted as necessary.

3.6.2 Machine Finishing with Slipform Pavers

The slipform paver shall be operated so that only a very minimum of additional finishing work is required to produce pavement surfaces and edges meeting the specified tolerances. Any equipment or procedure that fails to meet these specified requirements shall immediately be replaced or modified as necessary. A self-propelled nonrotating pipe float may be used while the concrete is still plastic, to remove minor irregularities and score marks. Only one pass of the pipe float shall be allowed. If there is concrete slurry or fluid paste on the surface that runs over the edge of the pavement, the paving operation shall be immediately stopped and the equipment, mixture, or operation modified to prevent formation of such slurry. Any slurry which does run down the vertical edges shall be immediately removed by hand, using stiff brushes or scrapers. No slurry, concrete or concrete mortar shall be used to build up along the edges of the pavement to compensate for excessive edge slump, either while the concrete is plastic or after it hardens.

3.6.3 Surface Correction and Testing

After all other finishing is completed but while the concrete is still plastic, minor irregularities and score marks in the pavement surface shall be eliminated by means of cutting straightedges. Such straightedges shall be 4 m 12 feet in length and shall be operated from the sides of the pavement and from bridges. A straightedge operated from the side of the pavement shall be equipped with a handle 1 m 3 feet longer than one-half the width of the pavement. The surface shall then be tested for trueness with a straightedge held in successive positions parallel and at right angles to the center line of the pavement, and the whole area covered as necessary to detect variations. The straightedge shall be advanced along the pavement in successive stages of not more than one-half the length of the straightedge. Depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated with an internal vibrator, and refinished. Projections above the required elevation shall also be struck off and refinished. The straightedge testing and finishing shall continue until the entire surface of the concrete is free from observable departure from the straightedge and conforms to the surface requirements specified in paragraph: ACCEPTABILITY OF WORK in PART 1. This straightedging shall not be used as a replacement for the straightedge testing of paragraph: Surface Smoothness in PART 1. Long-handled, flat bull floats shall be used very sparingly and only as necessary to correct minor, scattered surface defects. If frequent use of bull floats is necessary, the paving operation shall be stopped and the equipment, mixture or procedures adjusted to eliminate the surface defects. Finishing with hand floats and trowels shall be held to the absolute minimum necessary. Extreme care shall be taken to prevent overfinishing joints and edges. The surface finish of the pavement shall be produced essentially by the finishing machine and not by subsequent hand finishing operations. All hand finishing operations shall be subject to approval and shall be modified when directed.

3.6.4 Hand Finishing

Use hand finishing operations only as specified below.

3.6.4.1 Equipment and Template

In addition to approved mechanical internal vibrators for consolidating the concrete, provide a strike-off and tamping template and a longitudinal float for hand finishing. The template shall be at least 300 mm 1 foot

longer than the width of pavement being finished, of an approved design, and sufficiently rigid to retain its shape, and shall be constructed of metal or other suitable material shod with metal. The longitudinal float shall be at least 3 m 10 feet long, of approved design, and rigid and substantially braced, and shall maintain a plane surface on the bottom. Grate tampers (jitterbugs) shall not be used.

3.6.4.2 Finishing and Floating

As soon as placed and vibrated, the concrete shall be struck off and screeded to the crown and cross section and to such elevation above grade that when consolidated and finished, the surface of the pavement will be at the required elevation. In addition to previously specified complete coverage with handheld immersion vibrators, the entire surface shall be tamped with the strike-off and tamping template, and the tamping operation continued until the required compaction and reduction of internal and surface voids are accomplished. Immediately following the final tamping of the surface, the pavement shall be floated longitudinally from bridges resting on the side forms and spanning but not touching the concrete. If necessary, additional concrete shall be placed, consolidated and screeded, and the float operated until a satisfactory surface has been produced. The floating operation shall be advanced not more than half the length of the float and then continued over the new and previously floated surfaces.

3.6.5 Texturing

****

NOTE: Designer must select type of texturing desired, retain that subparagraph, and delete the others. A genuine effort should be made to determine the type of texturing, if any, desired by the using service. If no guidance is given, the usual default method should be burlap drag. Edit bracketed phrases as appropriate. For Air Force airfield paving projects, do not specify artificial turf, wire comb, or surface grooving textures. Use Section 32 01 26.71 GROOVING FOR AIRFIELD PAVEMENTS, to specify saw-cut grooves. If other than a burlap drag textured finish is required, add the appropriate paragraph(s) as shown below. Spring tine grooving is limited to use on roads and streets only.

****

Before the surface sheen has disappeared and before the concrete hardens or curing compound is applied, the surface of the pavement shall be given a texture as described herein. After curing is complete, all textured surfaces shall be thoroughly power broomed to remove all debris.

3.6.5.1 Burlap Drag Surface

Surface texture shall be applied by dragging the surface of the pavement, in the direction of the concrete placement, with an approved burlap drag. The drag shall be operated with the fabric moist, and the fabric shall be cleaned or changed as required to keep clean. The dragging shall be done so as to produce a uniform finished surface having a fine sandy texture without disfiguring marks.

3.6.5.2 Artificial Turf Drag Surface

Artificial turf texture shall be applied by dragging the surface of the pavement in the direction of concrete placement with an approved full-width drag made with artificial turf.

3.6.5.3 Broom Texturing

Brooming should be completed before the concrete has hardened to the point where the surface will be unduly torn or roughened, but after hardening has progressed enough so that the mortar will not flow and reduce the sharpness of the scores. Successive passes of the broom shall be overlapped the minimum necessary to obtain a uniformly textured surface. Brooms shall be washed thoroughly at frequent intervals during use. Worn or damaged brooms shall be removed from the job site. Hand brooming will be permitted only on isolated odd shaped slabs or slabs where hand finishing is permitted. For hand brooming, the brooms shall have handles longer than half the width of slab to be finished. The hand brooms shall be drawn transversely across the surface from the center line to each edge with slight overlapping strokes.

3.6.5.4 Wire-Comb Texturing

Surface texture shall be applied using an approved mechanical wire comb drag operated to comb the surface transverse to the pavement center line. The comb shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Successive passes of the comb shall be overlapped the minimum necessary to obtain a continuous and uniformly textured surface. Texturing shall be completed before the concrete has hardened to the point where the surface and edges will be unduly torn, but after hardening has progressed to the point where the serrations will not close up. The serrations shall be 2 to 5 mm 1/16 to 3/16 inch deep, 1.5 to 3 mm 1/16 to 1/8 inch wide, and spaced 9.5 mm 3/8 inch apart. Transverse texturing shall produce grooves in straight lines across each lane within a tolerance of plus or minus 13 mm 1/2 inch of a true line.

3.6.5.5 Surface Grooving

The areas indicated on the drawings shall be grooved with a spring tine drag producing individual grooves 6 mm 1/4 inch deep and 6 mm 1/4 inch wide at a spacing between groove centerlines of 37 mm 1-1/2 inches. These grooves shall be cut perpendicular to the centerline. Before grooving begins, the concrete shall be allowed to attain sufficient strength to prevent aggregate spalling. Grooves shall not be cut within 150 mm 6 inches of a runway centerline, transverse joint, or crack; and they shall not be cut through neoprene compression seals. Transverse texturing shall produce grooves in straight lines across each lane within a tolerance of plus or minus 13 mm 1/2 inch of a true line.

3.6.6 Edging

After texturing has been completed, the edge of the slabs along the forms, along the edges of slipformed lanes, and at the joints shall be carefully finished with an edging tool to form a smooth rounded surface of 3 mm 1/8 inch radius. Tool marks shall be eliminated, and the edges shall be smooth and true to line. No water shall be added to the surface during edging. Extreme care shall be taken to prevent overworking the concrete.

3.6.7 Outlets in Pavement

Recesses for the tie-down anchors, lighting fixtures, and other outlets in the pavement shall be constructed to conform to the details and dimensions shown. The concrete in these areas shall be carefully finished to provide a surface of the same texture as the surrounding area that will be within the requirements for plan grade and surface smoothness.

3.7 CURING

****
NOTE: Retain bracketed item at end of first paragraph mandating 24 hour moist cure only where locally required and only where approved by the using service. Membrane curing should be the first choice of curing methods.
****

3.7.1 Protection of Concrete

Concrete shall be continuously protected against loss of moisture and rapid temperature changes for at least 7 days from the completion of finishing operations. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. If any selected method of curing does not afford the proper curing and protection against concrete cracking, the damaged pavement shall be removed and replaced, and another method of curing shall be employed as directed. Curing shall be accomplished by one of the following methods [except that only moist curing shall be used for the first 24 hours].

3.7.2 Membrane Curing

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NOTE: The first Tailoring Option is for Army and Air Force jobs; the second option is for Navy projects only.
****

A uniform coating of white-pigmented, membrane-forming, curing compound shall be applied to the entire exposed surface of the concrete as soon as the free water has disappeared from the surface after [finishing] [moist curing ceases]. Along the formed edge faces, it shall be applied immediately after the forms are removed. Concrete shall not be allowed to dry before the application of the membrane. If any drying has occurred, the surface of the concrete shall be moistened with a fine spray of water, and the curing compound applied as soon as the free water disappears. The curing compound shall be applied to the finished surfaces by means of an approved automatic spraying machine. The curing compound shall be applied with an overlapping coverage that will give a two-coat application at a coverage of 10 square meters per L 400 square feet per gallon, plus or minus 5.0 percent for each coat. A one-coat application may be applied provided a uniform application and coverage of 5 square meters per L 200 square feet per gallon, plus or minus 5.0 percent is obtained. The curing compound shall be applied with a single overlapping application that will give a uniform coverage of 3.7 square meters/L 150 square feet per gallon. The application of curing compound by hand-operated, mechanical powered pressure sprayers will be permitted only on odd widths or shapes of slabs and on concrete surfaces exposed by the removal of forms. When the

application is made by hand-operated sprayers, a second coat shall be applied in a direction approximately at right angles to the direction of the first coat. If pinholes, abrasions, or other discontinuities exist, an additional coat shall be applied to the affected areas within 30 minutes. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified above. Areas where the curing compound is damaged by subsequent construction operations within the curing period shall be immediately resprayed. Concrete surfaces to which membrane-curing compounds have been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.7.3 Moist Curing

****
NOTE: For OCONUS projects using Silica Fume, specify a minimum 24-hour moist cure before applying membrane curing compound.
****

Concrete to be moist-cured shall be maintained continuously wet for the entire curing period, or until curing compound is applied, commencing immediately after finishing. If forms are removed before the end of the curing period, curing shall be carried out as on unformed surfaces, using suitable materials. Surfaces shall be cured by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap. Burlap and mats shall be clean and free from any contamination and shall be completely saturated before being placed on the concrete. Lap sheets to provide full coverage. Provide an approved work system to ensure that moist curing is continuous 24 hours per day and that the entire surface is wet.

3.8 JOINTS

****
NOTE: Edit bracketed items in following subparagraphs to conform to design requirements. Even if not required, dowels should be permitted for construction joints. The effect of tie bars on the pavement action and potential cracking should be analyzed before requiring or permitting their use. Remove joint types not required in the project.
****

3.8.1 General Requirements for Joints

Joints shall conform to the locations and details indicated and shall be perpendicular to the finished grade of the pavement. All joints shall be straight and continuous from edge to edge or end to end of the pavement with no abrupt offset and no gradual deviation greater than 13 mm 1/2 inch. Where any joint fails to meet these tolerances, the slabs adjacent to the joint shall be removed and replaced at no additional cost to the Government. No change from the jointing pattern shown on the drawings shall be made without written approval of the Contracting Officer. Joints shall be sealed immediately following curing of the concrete or as soon thereafter as weather conditions permit. Joints shall be sealed as specified in Section [32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN

RIGID PAVEMENTS] [32 13 73COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS].

3.8.2 Longitudinal Construction Joints

Dowels [or keys] [or tie bars] shall be installed in the longitudinal construction joints, or the edges shall be thickened as indicated. [Dowels] [Tie bars] shall be installed as specified above. [If any length of completed keyway of 1.5 m 5 feet or more fails to meet the previously specified tolerances, dowels shall be installed in that part of the joint by drilling holes in the hardened concrete and grouting the dowels in place with epoxy resin.] After the end of the curing period, longitudinal construction joints shall be sawed to provide a groove at the top for sealant conforming to the details and dimensions indicated.

3.8.3 Transverse Construction Joints

Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for 30 minutes or longer. The transverse construction joint shall be installed at a planned transverse joint. Transverse construction joints shall be constructed by utilizing headers or by paving through the joint, then full-depth sawcutting the excess concrete. Pavement shall be constructed with the paver as close to the header as possible, and the paver shall be run out completely past the header. Transverse construction joints installed at a planned transverse joint shall be constructed as shown or, if not shown otherwise, shall be dowelled in accordance with paragraph: Dowels Installed in Hardened Concrete, or paragraph: Fixed Form Paving above.

3.8.4 Expansion Joints

Expansion joints shall be formed where indicated, and about any structures and features that project through or into the pavement, using joint filler of the type, thickness, and width indicated, and shall be installed to form a complete, uniform separation between the structure and the pavement. The filler shall be attached to the original concrete placement with adhesive or other fasteners and shall extend the full slab depth. Adjacent sections of filler shall be fitted tightly together, and the filler shall extend across the full width of the paving lane or other complete distance in order to prevent entrance of concrete into the expansion space. Edges of the concrete at the joint face shall be finished with an edger with a radius of 3 mm 1/8 inch. The joint filler strips shall be installed 19 mm 3/4 inch below the pavement surface with a slightly tapered, dressed-and-oiled wood strip or other approved material temporarily secured to the top of the filler to form a recess to be filled with joint sealant.

3.8.5 Slip Joints

Slip joints shall be installed where indicated using the specified materials. Preformed joint filler material shall be attached to the face of the original concrete placement with adhesive or other fasteners. A19 mm 3/4 inch deep reservoir for joint sealant shall be constructed at the top of the joint. Edges of the joint face shall be finished with an edger with a radius of 3 mm 1/8 inch.

3.8.6 Contraction Joints

Construct transverse and longitudinal contraction joints by sawing an initial groove in the concrete with a 3 mm 1/8 inch blade to the indicated

depth. During sawing of joints, and again 24 hours later, the CQC team shall inspect all exposed lane edges for development of cracks below the saw cut, and shall immediately report results to the Contracting Officer. If the Contracting Officer determines that there are more uncracked joints than desired, the Contractor will be directed to saw succeeding joints 25 percent deeper than originally indicated at no additional cost to the Government. The time of initial sawing shall vary depending on existing and anticipated weather conditions and shall be such as to prevent uncontrolled cracking of the pavement. Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. The sawed faces of joints will be inspected for undercutting or washing of the concrete due to the early sawing, and sawing shall be delayed if undercutting is sufficiently deep to cause structural weakness or excessive roughness in the joint. The sawing operation shall be carried on as required during both day and night regardless of weather conditions. The joints shall be sawed at the required spacing consecutively in the sequence of the concrete placement. Adequate lighting shall be provided for night work. Illumination using vehicle headlights will not be permitted. A chalk line or other suitable guide shall be used to mark the alignment of the joint. Before sawing a joint, the concrete shall be examined closely for cracks, and the joint shall not be sawed if a crack has occurred near the planned joint location. Sawing shall be discontinued when a crack develops ahead of the saw cut. Immediately after the joint is sawed, the saw cut and adjacent concrete surface shall be thoroughly flushed with water and vacuumed until all waste from sawing is removed from the joint and adjacent concrete surface. The surface shall be resprayed with curing compound as soon as free water disappears. Necessary precautions shall be taken to insure that the concrete is properly protected from damage and cured at sawed joints. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed with cord backer rod before the concrete in the region of the joint is resprayed with curing compound, and shall be maintained until removed immediately before sawing the joint sealant reservoir. The exposed saw cuts on the faces of pilot lanes shall be sealed with bituminous mastic or masking tape. After expiration of the curing period, the upper portion of the groove shall be widened by sawing with ganged diamond saw blades to the width and depth indicated for the joint sealer. The reservoir shall be centered over the initial sawcut.

3.8.7 Thickened Edge Joints

Construct thickened edge joints as indicated on the drawings. Underlying material in the transition area shall be graded as shown and shall meet the requirements for smoothness and compaction specified for all other areas of the underlying material.

3.9 REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS

3.9.1 General Criteria

New pavement slabs that are broken, have spalled edges, or contain cracks shall be removed and replaced or repaired, as specified at no cost to the Government. Removal of partial slabs is not permitted. Not more than 15.0 percent of each slab's longitudinal joint edge shall be spalled. Prior to fill-in lane placement, pilot lane slabs with spalls exceeding this quantity, regardless of spall size, shall be sawn full depth to remove the spalled face. All other slabs shall be removed, as directed. The Contracting Officer will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine

depth of cracking. Such cores shall be at least 150 mm 6 inch diameter, and shall be drilled and backfilled with an approved non-shrink concrete. Perform drilling of cores and refilling holes at no expense to the Government.

3.9.2 Slabs with Cracks

Cracks that do not exceed 25 percent of the design thickness in depth shall be cleaned and then pressure injected full depth with epoxy resin, Type IV, Grade 1. Slabs containing cracks deeper than 25 percent of the design thickness shall be removed.

3.9.3 Removal and Replacement of Full Slabs

Where it is necessary to remove full slabs, removal shall be in accordance with paragraph: Removal of Existing Pavement Slab below. Removal and replacement shall be full depth, by full width of the slab, and the limit of removal shall be normal to the paving lane and extend to each original joint. Dowels of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified in paragraph: Placing Dowels and Tie Bars, above. Original damaged dowels or tie bars shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All four edges of the new slab shall thus contain dowels. Placement of concrete shall be as specified for original construction. Prior to placement of new concrete, the underlying material shall be recompacted and shaped as specified in the appropriate section of these specifications, and the surfaces of all four joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels or tie bars. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

3.9.4 Repairing Spalls Along Joints

Where directed, spalls along joints of new slabs, along edges of adjacent existing concrete, and along parallel cracks shall be repaired by first making a vertical saw cut at least 25 mm 1 inch outside the spalled area and to a depth of at least 50 mm 2 inches. Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and into at least 13 mm 1/2 inch of visually sound concrete. Spalls along joints to be sealed with compression seals shall be sawn, chipped out, and repaired to a depth to restore the full joint-face support. The cavity thus formed shall be thoroughly cleaned with high pressure water jets supplemented with oil-free compressed air to remove all loose material. Immediately before filling the cavity, a prime coat shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Prime coat for portland cement repairs shall be a neat cement grout and for epoxy resin repairs shall be epoxy resin, Type III, Grade 1. The prepared cavity shall be filled with: Portland cement concrete or latex modified mortar for larger cavities, those more than 0.009 cubic meter 1/3 cu. ft. in size after removal operations; Portland cement mortar for cavities between 0.00085 cubic meter 0.03 cu. ft. and 0.009 cubic meter 1/3 cu. ft.; and epoxy resin mortar or epoxy resin or latex modified mortar for those cavities less than 0.00085 cubic meter 0.03 cu. ft. in size. Portland cement concretes and mortars

shall be very low slump mixtures, 13 mm 1/2 inch slump or less, proportioned, mixed, placed, consolidated by tamping, and cured, all as directed. Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the Contracting Officer. Proprietary patching materials may be used, subject to approval by the Contracting Officer. The epoxy resin materials shall be placed in the cavity in layers not over 50 mm 2 inches thick. The time interval between placement of additional layers shall be such that the temperature of the epoxy resin material does not exceed 60 degrees C 140 degrees F at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or mortar. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints. The reservoir shall be thoroughly cleaned and then sealed with the sealer specified for the joints. [In lieu of sawing, spalls not adjacent to joints and popouts, both less than 150 mm 6 inches in maximum dimension, may be prepared by drilling a core 50 mm 2 inches in diameter greater than the size of the defect, centered over the defect, and 50 mm 2 inches deep or 13 mm 1/2 inch into sound concrete, whichever is greater. The core hole shall be repaired as specified above for other spalls.]

3.9.5 Repair of Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed voids or deleterious materials. Slabs containing weak surfaces less than 1/4 inch (6 mm) thick shall be diamond ground to remove the weak surface. Diamond grinding shall be in accordance with paragraph: Diamond Grinding of PCC Surfaces in PART 1. All ground areas shall meet the thickness, smoothness and grade criteria of paragraph: Acceptance Requirements in PART 1. Slabs containing weak surfaces greater than 6 mm 1/4 inch thick shall be removed and replaced.

3.9.6 Repair of Pilot Lane Vertical Faces

Excessive edge slump and joint face deformation shall be repaired in accordance with paragraph: Edge Slump and Joint Face Deformation in PART 1. Inadequate consolidation (honeycombing or air voids) shall be repaired by saw cutting the face full depth along the entire lane length with a diamond blade. Obtain cores, as directed, to determine the depth of removal.

3.10 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR

****
NOTE: It is imperative that sufficient exploration be made (not just reference to as-built drawings) for the designer to know exactly what the in-place existing pavement thickness and load-transfer are at the jointing area--dowels, keys, tie bars, etc--and its condition. Normally, the joint between the new pavement and existing pavement should be made at an existing joint in the old pavement. Coordinate with Section 02 41 00 DEMOLITION.
****

Existing concrete pavement shall be removed at locations indicated on the

drawings. Prior to commencing pavement removal operations, inventory the pavement distresses (cracks, spalls, and corner breaks) along the pavement edge to remain. After pavement removal, the remaining edge shall again be surveyed to quantify any damage caused by Contractor's removal operations. Perform both surveys in the presence of the Contracting Officer. Repairs shall be made as indicated and as specified herein. All operations shall be carefully controlled to prevent damage to the concrete pavement and to the underlying material to remain in place. All saw cuts shall be made perpendicular to the slab surface, forming rectangular areas.

3.10.1 Removal of Existing Pavement Slab

****
NOTE: The saw cut at a distance from the joint should be sawed with a wheel saw which produces a 38 mm (1-1/2 inch) or wider kerf and better prevents stress from propagating across the saw cut. Specify wheel saw for Army and Air Force projects. Specify diamond saw for Navy projects.
****

When existing concrete pavement is to be removed and adjacent concrete is to be left in place, the joint between the removal area and adjoining pavement to stay in place shall first be cut full depth with a standard diamond-type concrete saw. Next, a full depth saw cut shall be made parallel to the joint at least 600 mm 24 inches from the joint and at least 150 mm 6 inches from the end of any dowels. This saw cut shall be made with a [wheel saw] [diamond saw] as specified in paragraph: Sawing Equipment. All pavement to be removed beyond this last saw cut shall be removed in accordance with the approved demolition work plan. All pavement between this last saw cut and the joint line shall be removed by carefully pulling pieces and blocks away from the joint face with suitable equipment and then picking them up for removal. In lieu of this method, this strip of concrete may be carefully broken up and removed using hand-held jackhammers, 14 kg 30 lb or less, or other approved light-duty equipment which will not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. In lieu of the above specified removal method, the slab may be sawcut full depth to divide it into several pieces and each piece lifted out and removed. Suitable equipment shall be used to provide a truly vertical lift, and safe lifting devices used for attachment to the slab.

3.10.2 Edge Repair

The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Slabs which are damaged during construction shall be removed and replaced as directed by the Contracting Officer at no cost to the Government. Repair of previously existing damage areas will be considered a subsidiary part of concrete pavement construction. All exposed keyways shall be sawn off full depth.

3.10.2.1 Spall Repair

****
NOTE: Select the first Tailoring Option for Army and Air Force projects. The second option is for Navy projects only.
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Not more than 15.0 percent of each slab's edge shall be spalled as a result of the Contractor's actions. Slabs with spalls exceeding this quantity, regardless of spall size, shall be sawn full depth on the exposed face to remove the spalled face. Repair materials and procedures shall be as previously specified in paragraph: Repairing Spalls Along Joints. All slabs with spalls shall be repaired as directed by the Contracting Officer.

3.10.2.2 Underbreak and Underlying Material

All underbreak shall be repaired by removal and replacement of the damaged slabs in accordance with paragraph: Removal and Replacement of Full Slabs above. The underlying material adjacent to the edge of and under the existing pavement which is to remain in place shall be protected from damage or disturbance during removal operations and until placement of new concrete, and shall be shaped as shown on the drawings or as directed. Sufficient underlying material shall be kept in place outside the joint line to completely prevent disturbance of material under the pavement which is to remain in place. Any material under the portion of the concrete pavement to remain in place which is disturbed or loses its compaction shall be carefully removed and replaced with concrete.

3.11 PAVEMENT PROTECTION

Protect the pavement against all damage prior to final acceptance of the work by the Government. Aggregates, rubble, or other similar construction materials shall not be placed on airfield pavements. Traffic shall be excluded from the new pavement by erecting and maintaining barricades and signs until the concrete is at least 14 days old, or for a longer period if so directed. As a construction expedient in paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment will be permitted on the new pavement after the pavement has been cured for 7 days and the joints have been sealed or otherwise protected, the concrete has attained a minimum field cured flexural strength of 3.6 MPa 550 psi. and approved means are furnished to prevent damage to the slab edge. All new and existing pavement carrying construction traffic or equipment shall be continuously kept completely clean, and spillage of concrete or other materials shall be cleaned up immediately upon occurrence. Special care shall be used where Contractor's traffic uses or crosses active airfield pavement. Power broom other existing pavements at least daily when traffic operates. For fill-in lanes, equipment shall be used that will not damage or spall the edges or joints of the previously constructed pavement.

3.12 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL

3.12.1 Testing and Inspection by Contractor

During construction, the Contractor is responsible for sampling and testing aggregates, cementitious materials (cement, GGBF and pozzolan), and concrete to determine compliance with the specifications. Provide facilities and labor as may be necessary for procurement of representative test samples. Furnish sampling platforms and belt templates to obtain representative samples of aggregates from charging belts at the concrete plant. Samples of concrete shall be obtained at the point of delivery to the paver. Testing by the Government will in no way relieve the Contractor of the specified testing requirements. Perform the inspection and tests described below, and based upon the results of these inspections and tests, take the action required and submit reports as required. This testing shall be performed regardless of any other testing performed by the

Government, either for pay adjustment purposes or for any other reason.

3.12.2 Testing and Inspection Requirements

Contractor CQC sampling, testing, inspection and reporting shall be in accordance with the following Table.

TABLE 6
CONTRACTOR TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit/Corrective Action
	Fine Aggregate Gradation and Fineness Modulus	
2 per lot	ASTM C136 sample at belt	9 of 10 tests vary <0.15 from average Outside limits on any sieve-retest 2nd failure-stop, repair, retest
	Coarse Aggregate Gradation	
2 per lot	ASTM C136 sample at belt	Outside limits on any sieve-retest 2nd failure-report to COR, correct 2 consecutive avgs of 5 tests out- report to COR, stop ops, repair, retest
	Workability Factor and Coarseness Factor Computation	
Same as C.A. & F.A.	see paragraph: Aggregates	Use individual C.A. and F.A. gradations Combine using batch ticket percentages Tolerances: +/- 3 points on WF +/- 5 points on CF from approved mix design values Check batching tolerances, recalibrate scales
	Aggregate Deleterious, Quality, and ASR Tests	
Every [30] [60] days	see paragraph: AGGREGATES	Stop production, retest, replace aggregate Increase testing interval to 90 days if previous 2 tests pass
	Plant - Scales, Weighing Accuracy	
Monthly	NRMCA QC 3	Stop plant ops, repair, recalibrate
	Plant - Batching and Recording Accuracy	
Weekly	Record/Report	Record required/recorded/actual batch mass Stop plant ops, repair, recalibrate
	Plant - Batch Plant Control	
Every lot	Record/Report	Record type/amt of each material per lot
	Plant - Mixer Uniformity - Stationary Mixers	
Every 4 months during paving	COE CRD-C 55	After initial approval, use abbreviated method. Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest
	Plant - Mixer Uniformity - Truck Mixers	
Every 4 months during paving	ASTM C94/C94M	Random selection of truck. Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest.

Frequency	Test Method	Control Limit/Corrective Action
	Concrete Mixture - Air Content	
When test specimens prepared + 2 random	ASTM C231/C231M sample at paving site	Individual test control chart: Warning +/-1.0 - adjust AEA, retest Action +/-1.5 - halt ops, repair, retest Range between 2 consecutive tests: Warning +2.0 - recalibrate AEA dispenser Action +3.0 - halt ops, repair, retest
	Concrete Mixture - Unit Weight and Yield	
Same as Air content	ASTM C138/C138M sample at paving site	Individual test basis: Warning Yield -0/+1% - check batching tol. Action Yield -0/+5% - halt ops, recalibrate
	Concrete Mixture - Slump	
When test specimens prepared + 4 random	ASTM C143/C143M sample at paving site	Individual test control chart: Upper Warning - 13 mm 1/2 inch below max-adjust batch masses within max W/C ratio Upper Action - maximum allowable slump stop operations, adjust, retest Range between each consecutive test: 38 mm 1-1/2 inches stop operations, repair, retest
	Concrete Mixture - Temperature	
When test specimens prepared	ASTM C1064/C1064M sample at paving site	See paragraph: WEATHER LIMITATIONS
	Concrete Mixture - Strength	
8 per lot	ASTM C31/C31M sample at paving site	See Paragraph: Concrete Strength Testing for CQC
	Paving - Inspection Before Paving	
Prior to each paving operation	Report	Inspect underlying materials, construction joint faces, forms, reinforcing, dowels, and embedded items
	Paving - Inspection During Paving	
During each paving operation		Monitor and control paving operation, including placement, consolidation, finishing, texturing, curing, and joint sawing.
	Paving - Vibrators	
Weekly, during paving	COE CRD-C 521	Test frequency (in concrete), and amplitude (in air), measure at tip/head and average. Repair or replace defective vibrators.
	Moist Curing	
2 per lot, min 4 per day	Visual	Repair defects, extend curing by 1 day
	Membrane Compound Curing	
Daily	Visual	Calculate coverage based on quantity/area Respray areas where coverage defective Recalibrate equipment

Frequency	Test Method	Control Limit/Corrective Action
	Cold Weather Protection	
Once per	Visual	Repair defects, report conditions to COR

3.12.3 Concrete Strength Testing for Contractor CQC

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NOTE: If paragraph: Flexural Strength and Thickness is based on 28-day flexural strength for acceptance, modify this subparagraph to match it. The first option "Cylinders/Beams" includes items a through g; the second option "Beams" includes listing a through f.
****

Contractor Quality Control operations for concrete strength shall consist of the following steps:

a. Take samples for strength tests at the paving site. Fabricate and cure test cylinders in accordance with ASTM C31/C31M; test them in accordance with ASTM C39/C39M.

b. Fabricate and cure 2 test cylinders per sublot from the same batch or truckload and at the same time acceptance cylinders are fabricated and test them for compressive strength at 7-day age.

c. Average all 8 compressive tests per lot. Convert this average 7-day compressive strength per lot to equivalent [28] [90]-day flexural strength using the Correlation Ratio determined during mixture proportioning studies.

d. Compare the equivalent [28] [90]-day flexural strength from the conversion to the Average Flexural Strength Required for Mixtures from paragraph of same title.

e. If the equivalent average [28][90]-day strength for the lot is below the Average Flexural Strength Required for Mixtures by 138 kPa 20 psiflexural strength or more, at any time, adjust the mixture to increase the strength, as approved.

f. Fabricate and cure two beams for every 1500 cubic meters 2000 cubic yards of concrete placed. Fabricate and cure in accordance with ASTM C31/C31M; test at 14-days of age in accordance with ASTM C78/C78M. Use the flexural strength results to verify the cylinder-beam acceptance correlation ratio.

g. The Contractor's CQC testing agency shall maintain up-to-date control charts for strength, showing the 7-day CQC compressive strength, the 14-day compressive strength (from acceptance tests) and the [28] [90]-day equivalent flexural strength of each of these for each lot.

a. Take samples for strength tests at the paving site. Fabricate and cure test beams in accordance with ASTM C31/C31M; test them in accordance with ASTM C78/C78M.

b. Fabricate and cure 2 test beams per sublot from the same batch or truckload and at the same time acceptance beams are fabricated and test

them for flexural strength at 7-day age.

c. Average all 8 flexural tests per lot. Convert this average 7-day flexural strength per lot to equivalent [28] [90]-day flexural strength using the Correlation Ratio determined during mixture proportioning studies.

d. Compare the equivalent [28] [90]-day flexural strength from the conversion to the Average Flexural Strength Required for Mixtures from paragraph of same title.

e. If the equivalent average [28] [90]-day strength for the lot is below the Average Flexural Strength Required for Mixtures by 490 kPa 69 psi flexural strength or more, at any time, adjust the mixture to increase the strength, as approved.

f. The Contractor's CQC testing agency shall maintain up-to-date control charts for strength, showing the 7-day CQC flexural strength and the [28] [90]-day flexural strength (from acceptance tests) of each of these for each lot.

3.12.4 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. Prepare a weekly report for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, make daily reports of pertinent temperatures. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all Contractor quality control records.

-- End of Section --