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USACE / NAVFAC / AFCESA **UFGS-02751 (July 2004)**

Preparing Activity: NAVFAC **Superseding UFGS-02751N (November 2002)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 22 December 2004
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SECTION TABLE OF CONTENTS

DIVISION 02 - SITE CONSTRUCTION

SECTION 02751

AIRFIELDS AND HEAVY-DUTY CONCRETE PAVEMENT LESS THAN 10000 CUBIC YARDS

06/04

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SECTION 02751

AIRFIELDS AND HEAVY-DUTY CONCRETE PAVEMENT LESS THAN 10000 CUBIC YARDS
06/04

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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 and hardstands, and vehicular pavement less than 8000 cubic meters (10,000 cubic yards.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

This guide specification includes tailoring options for ARMY/AIR FORCE, AIR FORCE and NAVY. Selection or deselection of a tailoring option will include or exclude that option in the section, but editing the resulting section to fit the project is still required.

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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PART 1 GENERAL

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NOTE: In preparing contract specifications for concrete pavement, the designer will use UFC 3-250-04 STANDARD PRACTICE FOR CONCRETE PAVEMENTS for guidance. State highway specifications may only be used for non organizational parking, roads, streets, and driveways where the paving index is less than 5. All organizational vehicle parking,

roads and airfield concrete pavements will use the Unified Facilities guide specifications without exception. This UFGS or UFGS 02751N may be used for smaller quantity Navy projects. For smaller quantity Army or Air Force projects, use this UFGS or UFGS 02754A.

Contact the Corps of Engineers Transportation Systems Center (TSMCX), the Air Force Civil Engineer Support Agency (AFCESA), or the Navy's Engineering Field Divisions (EFD) or Naval Facilities Engineering Service Center (NFESC) 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, AFCESA, Navy EFD or NFESC for specification language.

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1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

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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.

ACI INTERNATIONAL (ACI)

ACI 211.1	(1991; R 2002) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 214R	(2002) Evaluation of Strength Test Results of Concrete
ACI 301	(1999) Specifications for Structural Concrete for Buildings
ACI 305R	(1999) Hot Weather Concreting
ACI 306R	(1988; R 2002) Cold Weather Concreting
ACI 325.9R	(1991; R 1997) Guide for Construction of Concrete Pavements and Bases

ASTM INTERNATIONAL (ASTM)

ASTM A 184/A 184M	(2001) Fabricated Deformed Steel Bar Mats

	for Concrete Reinforcement
ASTM A 497/A 497M	(2002) Steel Welded Wire Reinforcement, Deformed, for Concrete
ASTM A 615/A 615M	(2004b) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 775/A 775M	(2001) Epoxy-Coated Reinforcing Steel Bars
ASTM A 996/A 996M	(2004) Rail-Steel and Axle-Steel Deformed Bars or Concrete Reinforcement
ASTM C 1017/C 1017M	(2003) Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C 1064/C 1064M	(2004) Temperature of Freshly Mixed Portland Cement Concrete
ASTM C 1077	(2003a) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1116	(2003) Fiber-Reinforced Concrete and Shotcrete
ASTM C 117	(2004) Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 123	(2004) Lightweight Particles in Aggregate
ASTM C 1260	(2001) Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C 131	(2003) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(2004) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 142	(1997; R 2004) Clay Lumps and Friable Particles in Aggregates
ASTM C 143/C 143M	(2003) Slump of Hydraulic Cement Concrete
ASTM C 150	(2004a) Portland Cement
ASTM C 172	(2004) Sampling Freshly Mixed Concrete
ASTM C 174/C 174M	(1997) Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C 192/C 192M	(2002) Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	(2004) Air Content of Freshly Mixed

	Concrete by the Pressure Method
ASTM C 260	(2001) Air-Entraining Admixtures for Concrete
ASTM C 29/C 29M	(1997; R 2003) Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C 294	(2004) Standard Descriptive Nomenclature for Constituents of Concrete Aggregates
ASTM C 295	(2003) Petrographic Examination of Aggregates for Concrete
ASTM C 309	(2003) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 31/C 31M	(2003a) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(2003) Concrete Aggregates
ASTM C 39/C 39M	(2004) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 42/C 42M	(2004) Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 494/C 494M	(2004) Chemical Admixtures for Concrete
ASTM C 595	(2003) Blended Hydraulic Cements
ASTM C 618	(2003) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 78	(2002) Flexural Strength of Concrete (Using Simple Beam With Third-Point Loading)
ASTM C 88	(1999a) Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 881/C 881M	(2002) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 94/C 94M	(2004a) Ready-Mixed Concrete
ASTM C 989	(2004) Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM D 1751	(1999) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(2004a) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

ASTM D 2995	(1999; R 2004) Determining Application Rate of Bituminous Distributors
ASTM D 4791	(1999) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 75	(2003) Sampling Aggregates

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA QC 3	(2002) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 114	(1997) Test Method for Soundness of Aggregates by Freezing and Thawing of Concrete Specimens
COE CRD-C 130	(2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles
COE CRD-C 171	(1994) Standard Test Method for Determining Percentage of Crushed Particles in Aggregate
COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-24441/20	(Rev A) Paint, Epoxy-Polyamide, Green Primer, Formula 150, Type III
UFC 3-270-03	O&M: Concrete Crack and Partial-Depth Spall Repair

1.2 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 must conform to the requirements of both this section and the other section, including tolerances for both.

1.3 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" 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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment

a. A certified copy of the NRMCA QC Manual Section 3 Concrete Plant Certification Checklist.

b. A description of the equipment proposed for the machine and hand placing, consolidating and curing of the concrete mixture, method of control, and manufacturer's literature on the paver and finisher.

Proposed Techniques; G, [_____]

Placing and protection methods; paving sequence; jointing pattern; data on curing equipment; demolition of existing pavements; as specified.

SD-05 Design Data

Proportioning Studies; G, ED

The results of the mixture proportioning studies must be 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 must 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. Base aggregate quantities on the mass in a saturated surface dry condition. Accompany the recommended mixture proportions by test results demonstrating that the proportions selected will produce concrete of the qualities indicated. The submittal must include:

a. Coarse and fine aggregate gradations and plots.
b. Combined aggregate gradation and [coarseness/workability] plots.
c. Coarse aggregate quality test results, including deleterious materials.
d. Fine aggregate quality test results.
e. Mill certificates for cement, pozzolan, and GGBF slag.
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 for average CQC flexural strength increase.
i. Recommended proportions/volumes for proposed mixture and 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).

SD-06 Test Reports

Sampling and Testing; G, ED

Certified copies of laboratory test reports and sources for cement, pozzolan, GGBF, aggregates, admixtures, curing compound, epoxy, and proprietary patching materials proposed for use on this project. All aggregate tests must have been performed no earlier than 6 months prior to contract award.

Concrete Slump

Air Content

Pavement Thickness

Flexural Strength

Control Charts

SD-07 Certificates

Contractor Quality Control Staff; G, ED

American Concrete Institute certification for Contractor Quality Control staff. [Qualifications and resumes for petrographer and surveyor.]

Laboratory Accreditation; G, ED

Accreditation of the commercial laboratory by an independent evaluation authority, indicating conformance to ASTM C 1077, including all applicable test procedures.

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NOTE: The USACE validation letter requirement does not apply to the Navy.
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Commercial Laboratory; G, ED

USACE validation letter for commercial laboratory.

1.4 MEASUREMENT AND PAYMENT

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NOTE: Any project small enough to use this guide specification may use Unit Price or Lump Sum payment. If lump sum payment is used, delete the following paragraphs on Measurement and Payment. For Navy projects, obtain the permission of the affected Contracting Officer before using pay-for-performance.
****

1.4.1 Measurement

The quantity of concrete to be paid for will be the volume of concrete in cubic meters yards including 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 edges or the space occupied by embedded items or voids.

1.4.2 Payment

Payment will be made at the contract price per cubic meter yard for the scheduled item. 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. No separate payment will be made for any cementitious materials, admixtures, steel reinforcement, dowels or tie bars, or for any joint materials.

1.5 ACCEPTABILITY OF WORK

****
NOTE: Correlate this paragraph with paragraph SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES and all other specification requirements. The District Pavement Engineer or Geotechnical Branch should be consulted for guidance.
****

The pavement will be accepted on the basis of tests made by the Government and by the Contractor or its suppliers, in accordance with paragraph: Testing and Inspection for Contractor Quality Control and as specified herein. The Government may, at its discretion, make check tests to validate the results of the Contractor's testing. Take concrete samples at

the placement to determine the slump, air content, and strength of the concrete. Make test [beams] [cylinders] for determining conformance with the strength requirements of these specifications and, when required, for determining the time at which pavements may be placed into service. Determine all air content measurements in accordance with ASTM C 231. Perform all slump tests in accordance with ASTM C 143/C 143M. Fabricate all test [beams] [cylinders] in accordance with ASTM C 192/C 192M; cure in accordance with ASTM C 31/C 31M; and test in accordance with [ASTM C 78] [ASTM C 39/C 39M]. Ensure core samples to determine in-place thickness of the concrete pavement are in accordance with paragraph: Test for Pavement Thickness. Furnish all materials, labor, and facilities required for molding, curing, testing, and protecting test specimens and core samples at the site and in the laboratory.

1.5.1 Evaluation Sampling

Ensure sampling, testing, and mixture proportioning is performed by a commercial Testing Laboratory, conforming with ASTM C 1077. The individuals who sample and test concrete and concrete constituents must be certified as American Concrete Institute (ACI) Concrete Field Testing Technicians, Grade I. The individuals who perform the inspection of concrete must be certified as ACI Concrete Construction Inspector, Level II. All mix design, weekly quality control reports, smoothness reports, and project certification reports must be signed by a Registered Engineer.

1.5.2 Surface Testing

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NOTE: Drawings should clearly show all pavement joint intersection elevations, and specific required deviations from a plane surface for such special features as crowns, drainage inlets, etc.

****

Perform surface testing for surface smoothness [, edge slump] and plan grade as indicated below by the Testing Laboratory. Properly reference the measurements in accordance with paving lane identification and stationing, and a report given to the Government within 24 hours after measurement is made. Provide a final report of surface testing, signed by a Registered Engineer, containing all surface measurements and a description of all actions taken to correct deficiencies, to the Government upon conclusion of surface testing.

1.5.2.1 Smoothnesss

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NOTE: Delete or retain paragraphs in brackets for roads and streets features, as required.

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Straightedge Testing: Ensure the finished surfaces of the pavements have no abrupt change of 6 mm 1/4 inch or more, and all pavements are within the limits specified hereinafter when checked with an approved 4 m 12 foot straightedge. Ensure runways and taxiways 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. Ensure all other airfield areas have a variation from a straight edge not greater than 6 mm 1/4 inch in either the longitudinal or transverse

direction. [Ensure roads, streets, tank hardstands, vehicular parking areas, and open storage areas have a variation from the specified straight edge not greater than 6 mm 1/4 inch in either the longitudinal or transverse direction.]

1.5.2.2 Testing Method

Test the entire area of the pavement in both a longitudinal and a transverse direction on parallel lines approximately 4.5 m 15 feet apart. Hold the straightedge 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 straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length and measuring the maximum gap between the straightedge and the pavement surface, in the area between these two high points.

1.5.2.3 Plan Grade

Within 5 days after paving, test the finished surface of the pavement area by running lines of levels at intervals corresponding with every longitudinal and transverse joint to determine the elevation at each joint intersection. Record the results of this survey and provide a copy to the Government at the completion of the survey. Ensure the finished surfaces of airfield runway, taxiway, and apron pavements vary not more than 12 mm 1/2 inch above or below the plan grade line or elevation indicated. Ensure the surfaces of other pavements vary not more than 18 mm 3/4 inch.

1.5.2.4 Areas Defective in Plan Grade or Smoothness

In areas not meeting the specified limits for surface smoothness and plan grade, reduce high areas to attain the required smoothness and grade, at no additional cost to the Government. Reduce high areas by grinding the hardened concrete with an approved diamond grinding machine after the concrete is 14 days or more old. Ensure the depth of diamond grinding does not exceed 6 mm 1/4 inch. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above, in conformance with paragraph REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS.

1.6 ACCEPTABILITY OF WORK

The materials and the pavement itself will be accepted on the basis of tests made by the Contractor, using an approved commercial laboratory. All sampling and testing for preconstruction testing of materials shall be performed by, and at the expense of, the Contractor, using an approved commercial laboratory or, for cementitious materials and chemical admixtures, a laboratory maintained by the manufacturer of the material. 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. The Contractor must 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.

1.7 QUALIFICATIONS

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NOTE: Where they are available, specify only ACI

certified personnel. Check the American Concrete Institute (ACI) web site for local availability (www.concrete.org/Certification). Delete petrographer requirements for Navy projects.

****

1.7.1 Contractor Quality Control Staff

All Contractor Quality Control personnel assigned to concrete construction must be American Concrete Institute (ACI) certified in the following grade (or have written evidence acceptable to the Contracting Officer's representative of having completed similar qualification programs):

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

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

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

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

1.7.2 Other Staff

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

1. Petrographer: Bachelor of Science degree in geology or petrography, trained in petrographic examination of concrete aggregate according to ASTM C 294 and ASTM C 295 and trained in identification of the specific deleterious materials and tests identified in this specification. Resume must detail the education, training and experience related to the project-specific test methods and deleterious materials and be submitted at least 20 days before petrographic and deleterious materials examination is to commence.

2. Licensed Surveyor: All survey work must be performed under the supervision of a Licensed Surveyor.

1.7.3 Laboratory Accreditation

Laboratory and testing facilities must be provided by and at the expense of the Contractor. The laboratories performing the tests must be accredited in accordance with ASTM C 1077, including ASTM C 78 and ASTM C 1260. The accreditation must be current and must include the required and optional test methods, as specified throughout this SECTION. Provide onsite temperature-controlled concrete curing facilities.

1.8 DELIVERY, STORAGE, AND HANDLING OF MATERIALS

Deliver, store and handle cementitious materials, fine and coarse aggregates and other concreting materials in accordance with ASTM C 94/C 94M.

1.9 EQUIPMENT

Maintain all plant, equipment, tools, and machines used in the work in satisfactory working conditions at all times.

1.9.1 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 30 minutes haul time from the placing site during all periods of the work day. Edit bracketed items as appropriate.
****

Ensure the batching and mixing plant conforms to the requirements of NRMCA QC 3 [and be no more than 30 minutes haul time from the placing site]. There must be operable telephonic or radio communication between the plant and the placing site at all times concreting is taking place.

1.9.2 Truck Mixers

****
NOTE: Retain this subparagraph only if truck mixers have been permitted above.
****

Ensure truck mixers, the mixing of concrete therein, and concrete uniformity and testing thereof conforms to the requirements of ASTM C 94/C 94M. Additional water may be added to bring the slump within the specified range provided the approved water-cement ratio is not exceeded.

1.9.3 Paver-Finisher

The paver-finisher must be a heavy-duty, self-propelled machine designed specifically for paving and finishing high quality pavement. Clary screeds, other rotating tube floats, or bridge deck finishers must not be 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 must have a minimum operating weight of 4100 kg 9000 pounds and must have a transversely operating carriage containing a knock-down auger and a minimum of two immersion vibrators. Use vibrating screeds or pans only for isolated slabs where hand finishing is permitted as specified, and only where specifically approved. Concrete finishing equipment of types other than specified above may be demonstrated on a test section outside the production pavement if approved in writing.

1.9.4 Curing Equipment

Equipment must be self-propelled, with spraying nozzles and pressure that can be controlled and operated with a fine nozzle to completely and uniformly cover pavement surface with required amount of curing compound. It must mechanically agitate curing compound throughout application. Small or irregular areas may be sprayed by hand methods. Calibrate the spraying system in accordance with ASTM D 2995, Method A, for the rate of application required in paragraph: MEMBRANE CURING. Any hand-operated sprayers allowed by paragraph: MEMBRANE CURING must be compressed air supplied by a mechanical air compressor. Immediately replace curing equipment that fails to apply an even coating of compound at the specified rate.

1.9.5 Sawing Equipment

****
NOTE: Retain bracketed sentence as necessary to correlate with paragraph REMOVAL OF EXISTING PAVEMENT SLAB. Otherwise delete.
****

Ensure equipment for sawing joints and for other similar sawing of concrete is standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Use diamond tipped blades. 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 must 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.] Use saws 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 is permitted.

1.9.6 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 must be constructed of aluminum or magnesium alloy and have blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Straightedges must have handles for operation on the pavement.

1.10 PROPOSED TECHNIQUES

Submit plans for placing and protection methods; paving sequence; jointing pattern; data on curing equipment; demolition of existing pavements; and other techniques as specified to the Contracting Officer.

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 federal Government 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, Navy EFD, NFESC, or AFCESA, 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 3-250-04 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.

****

Ensure cementitious materials are portland cement, [blended cement] or only portland cement in combination with natural pozzolan or fly ash [or ground granulated blast furnace slag] and conforms to appropriate specifications listed below.

2.1.1 Portland Cement

Ensure portland cement conforms to ASTM C 150, Type [I] [II] [V], low alkali [except that the maximum amount of C3A in Type I cement shall be 15 percent] [including false set requirements] [Type III with C3A limited to 8 percent]. [Use Type III cement only in concrete in the following locations [_____].]

2.1.2 Blended Cements

****

NOTE: Blended cement is not used by the Navy.

****

Blended cement shall conform to ASTM C 595, Type [IP] [IP (MS)] [IS] [IS (MS)], including the optional requirement for mortar expansion.Not Used.

2.1.3 Pozzolan

2.1.3.1 Fly Ash

****

NOTE: For Navy projects, Class F fly ash is required in all paving concrete. For Army and Air Force projects, Class F fly ash is recommended, but not mandatory. 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.

****

Ensure fly ash conforms to ASTM C 618, Class F, including the optional requirements for drying shrinkage, uniformity, and effectiveness in controlling Alkali-Silica reaction and has a loss on ignition not exceeding [3] [6] percent. Ensure class F fly ash has a Calcium Oxide (CaO) content of less than 8 percent.

2.1.3.2 Raw or Calcined Natural Pozzolan

Ensure natural pozzolan is raw or calcined and conforms to ASTM C 618, Class N, including the optional requirements for drying shrinkage, uniformity, and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding [3] [6] percent. Ensure class N pozzolan has a Calcium Oxide (CaO) content of less than 5 percent.

2.1.4 Ground Granulated Blast-Furnace (GGBF) Slag

Ensure Ground Granulated Blast-Furnace Slag conforms to ASTM C 989, Grade 100 or Grade 120.

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 option for Army and Air Force; second option is for Navy projects only.
****

Aggregate must have a satisfactory service record in freezing and thawing of at least 5 years successful service in three concrete paving projects. The service record must 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 must have a durability factor of 50 or more when subjected to freezing and thawing in concrete in accordance with COE CRD-C 114. Evaluate and test fine and coarse aggregates to be used in all concrete for durability in accordance with ASTM C 88. Results must not show more than 18 percent loss when subjected to 5 cycles using Magnesium Sulfate. If Sodium Sulfate is used, results must not show more than 12 percent loss when subjected to 5 cycles.

2.2.1.2 Alkali-Silica Reactivity

****
NOTE: Use first and third options for Navy projects; use second option for Army and Air Force.
****

Evaluate and test fine and coarse aggregates to be used in all concrete for alkali-aggregate reactivity in accordance with ASTM C 1260. Test both coarse aggregate size groups if from different sources. Evaluate the fine and coarse aggregates separately and in combination, which matches the Contractor's proposed mix design proportioning, utilizing the modified version of ASTM C 1260. Test results of the combination must have a measured expansion equal to or less than 0.08 percent at 16 days after casting. Should the test data indicate an expansion of greater than 0.08 percent, reject the aggregate(s) or perform additional testing, using a modified version of ASTM C 1260 using one of the following options:Modify ASTM C 1260 as follows to included one of the following options:

a. Utilize the Contractor's proposed low alkali portland cement and Class F fly ash or Class N pozzolan in combination with the proposed aggregate percentage for the test proportioning. Use Class F fly ash or Class N pozzolan in the range of 25 percent to 40 percent of the total cementitious material by mass. 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 at 16 days after casting.

b. Utilize the Contractor's proposed low alkali portland cement and ground granulated blast furnace (GGBF) slag in combination with the proposed aggregate percentage for the test proportioning. Use GGBF slag in the range of 40 percent to 50 percent of the total cementitious material by mass. 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 at 16 days.

****
NOTE: The use of Lithium Nitrate for mitigation of alkali-silica reaction is an alternative for Navy projects only. However, do not include in a project specification without Navy EFD or NFESC concurrence.
****

c. Utilize the Contractor's proposed low alkali portland cement and a lithium nitrate admixture. The lithium nitrate admixture may be used in combination with either Class "F" fly ash, Class N pozzolan, or ground granulated blast furnace (GGBF) slag, at a dosage rate as recommended by the manufacturer.

If any of the above options does not lower the expansion to less than 0.08 percent at 16 days after casting, 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 Combined Aggregate Gradation

****
NOTE: For Air Force Projects include the following gradation requirements
****

In addition to the grading requirements specified for coarse aggregate and for fine aggregate, the combined aggregate grading must meet the following requirement.

a. The materials selected and the proportions used must 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 falls within the parallelogram described therein.

b. Determine the Coarseness Factor (CF) 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 cumulative percent passing the 2.36 mm No. 8 sieve. However, adjust WF 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. Plot a diagram 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, plot a parallelogram 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, change the grading of each size of aggregate used and the proportions selected as necessary.)

e. Use a blending aggregate to meet the required combined grading. This blending aggregate must be batched separately. Compute the combined grading of all aggregates used, in the proportions selected, on the basis of cumulative percent retained on each sieve specified for fine and coarse aggregate.

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.

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.

If reclaimed portland cement concrete is permitted, retain the bracketed portion regarding reclaimed PCC; otherwise, delete. If reclaimed PCC is permitted to be used, laboratory studies must be performed during the design stage to validate mixture proportions and to evaluate relative durability of the concrete produced.

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.

****

Ensure coarse aggregate consists of [[crushed] [uncrushed] gravel], crushed stone, [crushed adequately seasoned air-cooled iron blast-furnace slag; steel furnace slag will not be permitted], [reclaimed portland cement concrete] [or a combination thereof]. [Ensure crushed gravel contains not less than 75 percent of crushed particles by mass in each sieve size, as determined by COE CRD-C 171.] [Ensure aggregate used for paving compass calibration hardstands is free of materials having undesirable magnetic properties, including magnetite in granite, high-iron minerals in traprock, and pyrite in limestone.] [Ensure coarse aggregate used for paving power check pads is limestone, dolomite, basalt or other approved material which will not cause thermal distress from jet blast.] [Reclaimed concrete pavement or granular base produced from required removal operations may be used for aggregate, provided it meets all requirements specified herein for aggregates.] Ensure aggregates as delivered to the mixers consist of clean, hard, uncoated particles meeting the requirements of ASTM C 33 except as specified herein. [Wash coarse aggregate. Ensure washing is sufficient to remove dust and other coatings.] [Clean coarse aggregate by processing with an approved log washer.] [Ensure iron blast-furnace slag conforming to the grading to be used in the concrete has a compact density of not less than 1125 kg/cubic meter 70 lb/cu. ft. determined in accordance with ASTM C 29/C 29M]. Ensure coarse aggregate does not show more than 40 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C 131.

2.2.2.2 Particle Shape Characteristics

Ensure particles of the coarse aggregate are generally spherical or cubical in shape. Ensure the quantity of flat and elongated particles in any size

group does not exceed 20 percent by weight as determined by the Flat Particle Test and the Elongated Particle Test of ASTM D 4791. 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 levelling 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.
****

Ensure the nominal maximum size of the coarse aggregate is [37.5] [_____] mm [1.5] [_____] inches. When the nominal maximum coarse size is greater than 25 mm 1 inch, grade the coarse aggregates and furnish in two size groups meeting the individual grading requirements of ASTM C 33, Size No. 4 (37.5 to 19.0 mm) (1.5 to 0.75 inches) and Size No. 67 (19.0 to 4.75 mm) (0.75 inches to No. 4).

[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 TM 5-852-1. See ASTM C 33 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.

****

Ensure the amount of deleterious material in each size group of coarse aggregate doesl 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 C 142)	0.2	0.2	1.0
Shale (a) (ASTM C 295)	0.1	0.2	--
Material finer than 0.075 mm (No. 200 sieve) (b) (ASTM C 117)	0.5	0.5	1.0
Lightweight particles (c) (ASTM C 123)	0.2	0.2	1.0
Clay ironstone (d) (ASTM C 295)	0.1	0.5	--
Chert and cherty stone (less than 2.40 Mg/cubic meter density SSD (2.40 Sp. Gr.)) (e) ASTM C 123 followed by ASTM C 295)	0.1	0.5	--
Claystone, mudstone, and siltstone (f) (ASTM C 295)	0.1	0.1	--
Shaly and argillaceous limestone (g) (ASTM C 295)	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.

c. The separation medium must 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. Perform testing in accordance with the referenced test methods, except that the minimum sample size must be as specified in Paragraph: TESTING DELETERIOUS MATERIALS-AIRFIELDS ONLY.

]2.2.2.5 Testing Sequence Deleterious Materials -- Airfields Only

****
NOTE: Contact TSMCX for guidance on available petrographers in USACE. Use first option for Navy projects; second option applies to Army and Air Force.
****

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 must be in accordance with the referenced test methods. The size of the sample must be at least 90 kg 200 pounds for the 19 to 37 mm 3/4 to 1-1/2 inch 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 is as follows:

Step 1: Test full sample 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 C 142)	2.0
Material finer than 0.075 mm (No. 200 sieve) (ASTM C 117)	1.0
Lightweight particles (ASTM C 123)	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 must 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

Ensure fine aggregate consists of natural sand, manufactured sand, or a combination of the two, and is composed of clean, hard, durable particles. [Ensure aggregate used for paving compass calibration hardstands is free of materials having undesirable magnetic properties, including magnetite in granite, high-iron minerals in traprcok, and pyrite in limestone.] Irrespective of the source from which it is obtained, all fine aggregate must be composed of clean, hard, durable particles meeting the requirements of ASTM C 33. Stockpile and batch each type of fine aggregate separately. Particles of the fine aggregate must be generally spherical or cubical in shape.

2.2.3.2 Grading

Ensure grading of the fine aggregate, as delivered to the mixer, conforms to the requirements of ASTM C 33 and has 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 must not exceed the following limits by mass:

Material	Percentage by Mass
Clay lumps and friable particles ASTM C 142	1.0
Material finer than 0.075 mm (No. 200 sieve) ASTM C 117	3.0
Lightweight particles ASTM C 123 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 must conform to ASTM C 260. An accelerator conforming to ASTM C 494/C 494M, Type C, may be used only when specified in paragraph: SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES and must not be used to reduce the amount of cementitious material used. Calcium chloride and admixtures containing calcium chloride must not be used. Ensure retarding or water-reducing admixture meets the requirements of ASTM C 494/C 494M, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived. ASTM C 494/C 494M, Type F and G high range water reducing admixtures and ASTM C 1017/C 1017M admixtures must not be used.

2.3.2 Lithium Nitrate

****
NOTE: Contact the TSCMX, Navy EFD, NFESC, or AFCESA

before specifying Lithium Nitrate to mitigate Aggregate-Silica Reaction (ASR). Coordinate with manufacturer regarding Lithium Nitrate dosage.

****

Ensure the lithium admixture is a nominal 30 percent aqueous solution of Lithium Nitrate, with a density of 1.2 kilograms per liter 10 pounds per gallon, and has the approximate chemical form as shown below:

Constituent	Limit (Percent by Mass)
LiNo (Lithium Nitrate)	30 +/- 0.5
SO (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 must provide a trained representative to supervise the lithium nitrate admixture dispensing and mixing operations.

2.4 MEMBRANE FORMING CURING COMPOUND

****

NOTE: ASTM C 309 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 C 309, white-pigmented Type 2, Class B].

2.5 WATER

Water for mixing and curing must be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water may be used if it meets the requirements of ASTM C 94/C 94M.

2.6 JOINT MATERIALS

****

NOTE: Edit as appropriate for project requirements. Coordinate with UFGS 02760 and 02762 for Army and Air Force projects.

****

2.6.1 Expansion Joint Material

Expansion joint filler must be a preformed material conforming to [ASTM D 1751 or] [ASTM D 1752 Type [II] [III].] Expansion joint filler must be 20 mm 3/4 inch thick, and must be furnished in a single full depth piece.

2.6.2 Slip Joint Material

Slip joint material must be 6 mm 1/4 inch thick expansion joint filler conforming to para: EXPANSION JOINT MATERIAL.

2.7 REINFORCING

****

NOTE: Edit these paragraphs to conform to project requirements. Delete those not needed. Add epoxy-coated bars (ASTM A 775) or low-alloy bars (ASTM A 706) when required by design.

****

Ensure all reinforcement is 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, do not use reinforcing steel which is rusted to the extent that it does not conform to the required dimensions or mechanical properties.

2.7.1 Reinforcing Bars and Bar Mats

ensure reinforcing bars conform to [ASTM A 615/A 615M, billet-steel] [ASTM A 996/A 996M, rail and axle steel], Grade 60 [_____]. Ensure bar mats conform to ASTM A 184/A 184M. The bar members must be [billet] [rail] [axle] steel.

2.7.2 Deformed Welded Wire Reinforcement

Esure deformed Welded Wire Reinforcement conforms to ASTM A 497/A 497M, and is furnished in flat sheets.

2.7.2.1 Fiber Reinforcement

****

NOTE: Fibers may be used as an alternate for welded wire fabric used for secondary "reinforcement" (help control plastic shrinkage). Do not use fibers for a structural value. Fibers are required in concrete for AV-8 landing pad high temperature pavements.

****

ASTM C 1116. Use 100 percent virgin nylon or polypropylene fibers, 23 micron diameter, 19 mm 3/4 inch length with a minimum tensile strength of 482 MPa 70 ksi. Add fibers to the concrete mix at the batch plant at the rate of 0.89 kg per cubic meter 1.5 lbs. per cubic yard.

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 must be single piece bars fabricated or cut to length at the shop or mill before delivery to the site. Ensure dowels are free of loose, flaky rust and loose scale and are 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 must be plain (non-deformed) steel bars conforming to ASTM A 615/A 615M, Grade 40 or 60; ASTM A 996/A 996M, Grade 50 or 60. Ensure paint for dowels conforms to MIL-DTL-24441/20. As an alternate to paint, epoxy coatings conforming to ASTM A 775/A 775M may be used. Ensure grout retention rings are fully

circular metal or plastic devices capable of supporting the dowel until the epoxy hardens.

2.8.2 Dowel Bar Assemblies

Dowel bar assemblies must 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. ensure the dowels are 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

Ensure tie bars are deformed steel bars conforming to ASTM A 615/A 615M, or ASTM A 996/A 996M, 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, must not be used for bars that are bent and straightened during construction. Refer to Section 02390 MOORING AND GROUNDING POINTS FOR AIRCRAFT.

2.9 EPOXY RESIN

Ensure all epoxy-resin materials are two-component materials conforming to the requirements of ASTM C 881/C 881M, Class as appropriate for each application temperature to be encountered, except that in addition, the materials must meet the following requirements:

a. Material for use for embedding dowels and anchor bolts must 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 must be Type III, Grade as approved.

c. Material for use for injecting cracks must 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 must be Type V, Grade as approved.

2.10 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, without excessive cement content. 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 paragraph, Flexural Strength and Thickness. Be sure this and succeeding paragraphs correlate.
****

2.10.1 Specified Flexural Strength

****
NOTE: The designer has the option BEAMS or CYLINDERS/BEAMS to specify flexural strength for concrete. Use first sentence option for BEAMS and second sentence option for CYLINDERS/BEAMS.
****

Specified flexural strength, R, for concrete is [_____] MPa psi at [28] [90] days, [as determined by tests made in accordance with ASTM C 78 of beams fabricated and cured in accordance with ASTM C 192/C 192M][as determined by equivalent flexural strength, as specified in paragraph: Mixture Proportioning for Flexural Strength]. 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 pozzolan, and ground granulated blast furnace slag by the mass equivalency method described in ACI 211.1. The concrete must be air-entrained with a total air content of [_____] plus or minus 1.5 percentage points, at the point of placement. Determine air content in accordance with ASTM C 231. The maximum allowable slump of the concrete at the point of placement is 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 is applicable to both pilot and fill-in lanes.

2.10.2 Concrete Temperature

The temperature of the concrete as delivered must conform to the requirements of paragraphs: PAVING IN HOT WEATHER and PAVING IN COLD WEATHER. Determine temperature of concrete in accordance with ASTM C 1064/C 1064M.

2.10.3 Concrete Strength for Final Acceptance

****
NOTE: The designer has the option to specify concrete strength by using CYLINDERS/BEAMS or BEAMS. Use first bracketed sentence for CYLINDERS/BEAMS and the scond bracketed sentence for 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.][The strength of the concrete will be considered acceptable when the [90-day] [28-day] flexural strengths for each lot are above the'Specified Flexural Strength'.]

2.11 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.

****

2.11.1 Composition

****

NOTE: Use the first option for Army and Air Force jobs; use the second option for Navy jobs only.

For concrete exposed to high temperatures under F/A-18 or B-1 auxiliary power unit exhaust the following mix (per cubic yard) can be used as a guide:

Type I-II low alkali cement	**529 pounds**
Fly ash Class F	**176 pounds**
Expanded Shale Coarse Aggregate (e.g. Stalite or Haydite 3/4 to #4)	**800 pounds**
Expanded Shale Fine Aggregate (e.g. Stalite or Haydite minus #4)	**926 pounds**
Water	**35 gallons**
Slump (superplasticizer allowed)	**4 inches**
Air	**5-8%**
Water/Cementitious Ratio	**0.41**
Flexural Strength at [56] days	**4.5 MPa [650 psi]**
Compressive Strength at [56] days	**34.5 MPa [5000psi]**

Final weight (per cubic yard) will be affected by the actual aggregate density. Solite aggregate has also been used successfully.

For AV-8 applications add fibers in accordance with paragraph 2.1.4., or use trap rock.

Magnesium ammonium phosphate cement (such as Set 45) will provide increased resistance to thermal and chemical deterioration, but will result in very expensive concrete that sets very quickly.

****

Ensure concrete is composed of cementitious material, water, fine and coarse aggregates, and admixtures. Class F flyash or Class N Pozzolan, if used with non alkali reactive aggregates, must consist of not less than 15 percent of the cementitious material by mass and not more than 35 percent. GGBF slag, if used with non alkali reactive aggregates, must consist of not less than 20 percent of the cementitious material by mass and not more than 50 percent. If Class F fly ash, Class N pozzolan, or GGBF slag is required to mitigate potential alkali-aggregate reactivity, the percentage by mass, as determined from the modified ASTM C 1260 testing must be used in the mixture proportioning studies. Use Class F pozzolan or GGBF slag in all concrete mixtures. Class F pozzolan must consist of not less than 25 percent of cementitious materials by mass and not more than 40 percent. GGBF slag must consist of not less than 40 percent of the cementitious material by mass and not more than 50 percent. The total cementitious material content must be at least [280 kg/cubic meter 470 lb./cu. yd.] [310 kg/cubic meter 517 lb./cu. yd.]. Ensure admixtures consist of air entraining admixture [and also includes] [and may also include, as

approved] [accelerator] [retarder] [water-reducing admixture].

2.11.1.1 Concrete for High Temperature Pavements

Ensure concrete exposed to high temperatures under jet exhaust conforms to one of the following mixes:

Concrete exposed to the auxiliary power unit of F/A-18 and B-1 aircraft should use expanded shale for both the coarse and fine aggregate.

Concrete in AV-8 landing pads should use expanded shale for both the coarse and fine aggregate, and fibers in accordance with paragraph: FIBER REINFORCEMENT.

Alternatively, concrete in continuously reinforced AV-8 landing pads can include fine grained trap rock from unweathered diabase or basalt.

2.11.2 Proportioning Studies

Trial design batches, mixture proportioning studies, and testing requirements are the responsibility of the Contractor. Base trial mixtures having proportions, slumps, and air content suitable for the work on methodology described in ACI 211.1, modified as necessary to accommodate flexural strength.

2.11.2.1 Water-Cement Ratio

Use at least three different water-cement ratios, which will produce a range of strength encompassing that required on the project. The maximum allowable water-cement ratio required in paragraph: SPECIFIED FLEXURAL STRENGTH will be the equivalent water-cement ratio as determined by conversion from the mass ratio of water to cement plus pozzolan, and ground granulated blast furnace (GGBF) slag by the weight equivalency method as described in ACI 211.1. In the case where GGBF slag is used, include the mass of the GGBF slag in the equations in ACI 211.1 for the term P, which is used to denote the mass of pozzolan. Proporation laboratory trial mixtures for maximum permitted slump and air content.

2.11.2.2 Trial Mixture Studies

Make separate sets of trial mixture studies for each combination of cementitious materials and each combination of admixtures proposed for use. Do not use a combination of either 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. Design each mixture to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.

2.11.2.3 Mixture Proportioning Procedure

The Contractor must perform the following:

a. Fabricate, cure and test 6 test specimens per age for each mixture at 28 [ ] and 90 [ ] days.

b. Using the average strength for each w/(c+p), plot the results from each mixture on separate graphs for w/(c+p) versus 28-day strength.

c. From the graphs select a w/(c+p) which will produce a mixture giving a 28-day strength equal to the required strength.

2.11.3 Average Strength Required for Mixtures

In order to ensure meeting, during production, the strength requirements specified, the mixture proportions selected must produce a required average strength, f'cr, exceeding the specified strength, f'c, in accordance with procedures in Chapter 3 of ACI 301, "Proportioning."

PART 3 EXECUTION

3.1 PREPARATION FOR PAVING

Before commencing paving, perform the following:

Ensure forms are in place, cleaned, coated, and adequately supported.

Ensure equipment for spreading, consolidating, screeding, finishing, and texturing concrete is at the paving site, clean and in proper working order.

Ensure all equipment and material for curing and for protecting concrete from weather or mechanical damage is 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 must 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.

3.2 CONDITIONING OF UNDERLYING MATERIAL

Underlying material, [subgrade] [base course] [subbase course], upon which concrete is to be placed must be clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. After the underlying material has been prepared for concrete placement, no equipment is permitted thereon.

3.3 WEATHER LIMITATIONS

3.3.1 Placement and Protection During Inclement Weather

Follow practice found in ACI 325.9R, Chapter 10.

3.3.2 Paving in Hot Weather

The temperature of concrete must not exceed 32 degrees C. 90 degrees F. Ensure steel forms, dowels and reinforcing is cooled prior to concrete placement when steel temperatures are greater than 49 degrees C 120 degrees F. Follow practices found in ACI 305R.

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.

3.3.4 Paving in Cold Weather

Ensure cold weather paving conforms to ACI 306R. Do not begin placement of concrete unless the ambient temperature is at least 2 degrees C 35 degrees F and rising. Thereafter, halt placement of concrete 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, ensure the temperature of the concrete when placed is not less than 10 degrees C 50 degrees F nor more than 25 degrees C 75 degrees F. Ensure materials entering the mixer are free from ice, snow, and frozen lumps. Do not incorporate salt, chemicals or other materials in the concrete to prevent freezing. If allowed under paragraph: MIXTURE PROPORTIONS, an accelerating admixture may be used when the ambient temperature is below 10 degrees C 50 degrees F. Provide covering and other means 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.

3.4 CONCRETE PRODUCTION

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

Ensuyre batching, mixing, and transporting conforms to ASTM C 94/C 94M. The equipment must have a capacity sufficient to maintain a continuous, uniform forward movement of the paver. A batch ticket from the operator of the batching plant must accompany every load of concrete delivered to the paving site. Ensure tickets are on approved forms and 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. Deliver tickets to the placing foreman who must keep them on file and deliver them to the Government weekly.

3.5 PAVING

****
NOTE: Designer must correlate these paragraphs with paragraph EQUIPMENT. UFGS 02753 should be used if slip form paving operations are anticipated.
****

3.5.1 General Requirements

Construct pavement with paving and finishing equipment utilizing rigid fixed forms or by use of slipform paving equipment. Control paving equipment and its operation, and coordinate 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.

3.5.2 Consolidation

Consolidate concrete 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. Insert the vibrators 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.

3.5.3 Fixed Form Paving

Ensure paving equipment for fixed-form paving and its operation conforms to the requirements of paragraph EQUIPMENT, all requirements specified above under paragraph PAVING and as specified herein.

3.5.3.1 Forms for Fixed Form Paving

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

a. Ensure straight forms are made of steel and furnished in sections not less than 3 m 10 feet in length. Use flexible or curved forms of proper radius for curves of 31 m 100-foot radius or less. Ensure wood forms for curves and fillets are made of well-seasoned, surfaced plank or plywood, straight, and free from warp or bend. Ensure wood forms are adequate in strength and rigidly braced. Forms must have a depth equal to the pavement thickness at the edge. Maximum vertical deviation of top of any side form, including joints, must 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.

b. Tightly lock form sections and ensure they are free from play or movement in any direction. Provide forms 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. Do not place concrete until setting of forms has been checked and approved by the CQC team.

d. For overlay pavements and for other locations where forms must be set on existing pavements, hold forms securely in place with stakes or by other approved methods. Holes in existing pavements for form stakes must be carefully drilled by methods which will not crack or spall the existing pavement. After use, fill the holes flush with the surrounding surface using approved material, prior to overlying materials being placed. Immediately discontinue any method which does not hold the form securely or

which damages the existing pavement. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location and do not proceed further until the proposed method is approved by the Contracting Officer.

3.5.4 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.
****

3.5.4.1 General

Ensure paving equipment for slipform paving and its operation conforms to the requirement of paragraph EQUIPMENT and all requirements specified above.

3.5.4.2 Guidelines for Slipform Paving

Guidelines must be accurately and securely installed well in advance of concrete placement. Provide supports at necessary intervals to eliminate all sag in the guideline when properly tightened. Ensure the guideline is high strength wire set with sufficient tension to remove all sag between supports. Securely stake supports to the underlying material or make other provisions 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.

3.5.4.3 Laser Controls

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

3.5.5 Placing Reinforcing Steel

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

Position the reinforcement on suitable chairs securely fastened to the subgrade prior to concrete placement. Vibrate concrete after the steel has been placed. Regardless of placement procedure, ensure the reinforcing steel is free from coatings which could impair bond between the steel and concrete, and indicate laps in the reinforcement as indicated. In lieu of the above, automatic reinforcement depressing attachments may be used to position the reinforcement provided the entire operation is approved by the Contracting Officer. Regardless of the equipment or procedures used for installing reinforcement, ensure that the entire depth of concrete is adequately consolidated.

3.5.6 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 must 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 must be within a tolerance of plus or minus 15 mm 5/8 inch. Check the horizontal alignment with a framing square. Do not place dowels [and tie bars] 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 must be moved away from the joint to a location 0.6 time the dowel bar [tie bar] length. Install dowels as specified in the following subparagraphs.

3.5.6.1 Contraction Joints

Hold dowels [and tie bars] in longitudinal and transverse contraction joints within the paving lane securely in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. Hold the basket assemblies securely in the proper location by means of suitable pins or anchors.

3.5.6.2 Construction Joints-Fixed Form Paving

Install dowels [and tie bars] using the bonded-in-place method. Do not install by removing and replacing in preformed holes. Prepare dowels [and tie bars] and place 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.

3.5.6.3 Dowels Installed In Hardened Concrete

****
NOTE: The first 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. Drill holes approximately 3 mm 1/8 inch greater in diameter than the dowels into the hardened concrete. Repair any damage to the concrete face during drilling as directed. Bond dowels in the drilled holes using epoxy resin. Inject epoxy resin 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. Do not apply by buttering the dowel. Hold the dowels 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.

3.5.6.4 Lubricating Dowel Bars

Wipe clean the portion of each dowel intended to move within the concrete or expansion cap and coat with a thin, even film of lubricating oil before the concrete is placed.

3.6 FINISHING

****
NOTE: Edit bracketed items as appropriate. Retain slipform paving subparagraph only when it is acceptable. Delete Other Types of Finishing Equipment here and in PART 1, 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. Provide initial finishing by the transverse screed or extrusion plate. The sequence of operations are transverse finishing, longitudinal machine floating if used, straightedge finishing, texturing, and then edging of joints. Finish by the machine method. Use the hand method only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Keep supplemental hand finishing for machine finished pavement to an absolute minimum. Make every effort to prevent bringing excess paste to the surface and halt any operations which produce more than 3 mm 1/8 inch of paste (mortar, water, laitance, etc.) over the top layer of coarse aggregate immediately and the equipment, mixture, or procedures modified as necessary.

3.6.1 Machine Finishing With Fixed Forms

Use a machine designed to ride the forms and operate to screed and consolidate the concrete. Replace machines that cause displacement of the forms. 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, immediately stop the operation and the equipment, mixture, and procedures adjusted as necessary.

3.6.2 Machine Finishing with Slipform Pavers.

Operate the slipform paver so that only a very minimum of additional finishing work is required to produce pavement surfaces and edges meeting the specified tolerances. A self-propelled nonrotating pipe float may be used while the concrete is still plastic, to remove minor irregularities and score marks. allow only one pass of the pipe float. If there is concrete slurry or fluid paste on the surface that runs over the edge of the pavement, immediately stop the paving operation and the equipment, mixture, or operation modified to prevent formation of such slurry.

3.6.3 Surface Correction and Testing

After all other finishing is completed but while the concrete is still plastic, eliminate minor irregularities and score marks in the pavement surface by means of cutting straightedges. Use straightedges 4 m 12 feet in length and operate from the sides of the pavement and from bridges. Equip a straightedge operated from the side of the pavement with a handle 1 m 3 feet longer than one-half the width of the pavement. Then test the

surface 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. Advance the straightedge along the pavement in successive stages of not more than one-half the length of the straightedge. Immediately fill depressions with freshly mixed concrete, then strike off, consolidate, and refinish. Strike off and refinish projections above the required elevation. Produce the surface finish of the pavement essentially by the finishing machine and not by subsequent hand finishing operations. All hand finishing operations are subject to approval and must be modified when directed.

3.6.3.1 Edge Slump

Determine slump of edges with a 3.66 m 12 foot straightedge. Before the concrete hardens, correct edge slump of pavement exceeding 6 mm 1/4 inch at edge of pavement. Limit the area affected by the downward movement of the concrete along the pavement edge to not more than 450 mm 18 inches from the edge.

3.6.4 Hand Finishing

As soon as placed and consolidated, strike off and screed concrete to required cross section. If necessary, place and screed additional concrete and float until a satisfactory surface has been produced. Advance floating operation not more than half the length of the float and then continue over new and previously floated surfaces. Limit hand finishing to small irregular areas not accessible with finishing machine.

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 or wire comb textures. Use UFGS-02981A, GROOVING FOR AIRFIELD PAVEMENTS, to specify saw-cut grooves. If other then 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, give the surface of the pavement a texture as described herein. After curing is complete, thoroughly power broom all textured surfaces to remove all debris.

3.6.5.1 Burlap Drag Surface

Apply surface texture by dragging the surface of the pavement, in the direction of the concrete placement, with an approved burlap drag. Operate the drag with the fabric moist, and the fabric clean; change as required to keep clean. Perform the dragging so as to produce a uniform finished surface having a fine sandy texture without disfiguring marks.

3.6.5.2 Artificial Turf Drag Surface

Apply artificial turf texture by dragging the surface of the pavement in the direction of concrete placement with an approved full-width drag made with artificial turf. Ensure at least 600 mm 2 feet of the artificial turf is in contact with the concrete surface during texturing operations. Ensure the corrugations are uniform in appearance and approximately 2 mm 1/16 inch in depth.

3.6.5.3 Broom Texturing

Apply surface texture 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 must be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Overlap successive passes of the broom the minimum necessary to obtain a uniformly textured surface. Wash brooms thoroughly at frequent intervals during use. Remove worn or damaged brooms from the job site. Complete crooming 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. Ensure the scores are uniform in appearance and approximately 1.5 mm 1/16 inch in depth but not more than 3 mm 1/8 inch in depth. Hand brooming is permitted only on isolated odd shaped slabs or slabs where hand finishing is permitted. For hand brooming, use brooms with handles longer than half the width of slab to be finished. Draw the hand brooms transversely across the surface from the center line to each edge with slight overlapping strokes.

3.6.5.4 Wire-Comb Texturing

Apply surface texture using an approved mechanical wire comb drag operated to comb the surface transverse to the pavement center line. Use a comb capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Overlap successive passes of the comb the minimum necessary to obtain a continuous and uniformly textured surface. Complete texturing 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. Ensure the serrations are 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. Produce transverse texturing grooves in straight lines across each lane within a tolerance of plus or minus 12 mm 1/2 inch of a true line.

3.6.6 Edging

After texturing has been completed, carefully finish the edge of the slabs along the forms, along the edges of slipformed lanes, and at the joints with an edging tool to form a smooth rounded surface of 3 mm 1/8 inch radius. Eliminate tool marks, smooth the edges and make true to line. Do not add water to the surface during edging. Take extreme care to prevent overworking the concrete.

3.6.7 Outlets in Pavement

Construct recesses for the tie-down anchors, lighting fixtures, and other outlets in the pavement to conform to the details and dimensions shown. Carefully finish the concrete in these areas 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

Continuously protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the completion of finishing operations. Keep all equipment needed for adequate curing and protection of the concrete 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, remove and replace the damaged pavement, and employ another method of curing as directed. Accomplish curing by one of the following methods [except use only moist curing for the first 24 hours].

3.7.2 Membrane Curing

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

Apply a uniform coating of white-pigmented, membrane-forming, curing compound 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, apply it immediately after the forms are removed. Do not allow concrete to dry before the application of the membrane. If any drying has occurred, moisten the surface of the concrete with a fine spray of water, and apply the curing compound as soon as the free water disappears. Apply the curing compound to the finished surfaces by means of an approved automatic spraying machine. Apply the curing compound 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. Apply the curing compound with a single overlapping application that will give a uniform coverage of 3.7 square meters/L 150 square feet per gallon. Permit the application of curing compound by hand-operated, mechanical powered pressure sprayers 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, apply a second coat in a direction approximately at right angles to the direction of the first coat. If pinholes, abrasions, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied by the method and at the coverage specified above. Immediately respray areas where the curing compound is damaged by subsequent construction operations within the curing period. Protect concrete surfaces to which

membrane-curing compounds have been applied 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

Maintain concrete to be moist-cured 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, perform curing as on unformed surfaces, using suitable materials. Cure surfaces by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap. Use burlap and mats that are clean and free from any contamination and completely saturate before placing on the concrete. Lap sheets to provide full coverage. The Contractor must have 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 must conform to the locations and details indicated and must be perpendicular to the finished grade of the pavement. Ensure all joints are straight and continuous from edge to edge or end to end of the pavement with no abrupt offset and no gradual deviation greater than 12 mm 1/2 inch. Where any joint fails to meet these tolerances, remove the slabs adjacent to the joint and replace at no additional cost to the Government. Make no change from the jointing pattern shown on the drawings without written approval of the Contracting Officer. Seal joints immediately following curing of the concrete or as soon thereafter as weather conditions permit. Seal joints as specified in Section [02760 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS] [02762 COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS].

3.8.2 Longitudinal Construction Joints

Install dowels [or tie bars] in the longitudinal construction joints, or thicken the edges as indicated. Install [dowels] [tie bars] in conformance with paragraph, Placing Dowels and Tie Bars. After the end of the curing period, saw longitudinal construction joints to provide a groove at the top for sealant conforming to the details and dimensions indicated.

3.8.3 Transverse Construction Joints

Install transverse construction joints 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. Install the transverse

construction joint at a planned transverse joint. Construct transverse construction joints by utilizing headers or by paving through the joint, then full-depth sawcutting the excess concrete. Construct pavement with the paver as close to the header as possible, and run out the paver completely past the header. Construct transverse construction joints installed at a planned transverse joint as shown or, if not shown otherwise, use dowels. Insert dowels through the header into the fresh concrete and consolidated with hand-held vibrators.

3.8.4 Expansion Joints

Form expansion joints 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 install to form a complete, uniform separation between the structure and the pavement. Attach the filler to the original concrete placement with adhesive or other fasteners and extend the full slab depth. Fit adjacent sections of filler tightly together, and extend the filler across the full width of the paving lane or other complete distance in order to prevent entrance of concrete into the expansion space. Finish edges of the concrete at the joint face with an edger with a radius of 3 mm 1/8 inch. Install the joint filler strips 20 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. Construct expansion joints with [dowels] [thickened edges] for load transfer.

3.8.5 Slip Joints

Install slip joints where indicated using the specified materials. Attach preformed joint filler material to the face of the original concrete placement with adhesive or other fasteners. Construct a 20 mm 3/4 inch deep reservoir for joint sealant at the top of the joint. Finish edges of the joint face 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 must inspect all exposed lane edges for development of cracks below the saw cut, and 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. Commence sawing of the joints as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. Use a chalk line or other suitable guide to mark the alinement of the joint. Immediately after the joint is sawed, thoroughly flush the saw cut and adjacent concrete surface with water and vacuum until all waste from sawing is removed from the joint and adjacent concrete surface. Respray the surface with curing compound as soon as free water disappears. Take necessary precautions to ensure that the concrete is properly protected from damage and cured at sawed joints, but that no curing compound enters the joints. Tightly seal the top of the joint opening and the joint groove at exposed edges with cord backer rod before the concrete in the region of the joint is resprayed with curing compound, and maintain until removed immediately before sawing joint sealant reservoir. After expiration of the curing period, widen the upper portion

of the groove by sawing to the width and depth indicated for the joint sealer.

3.8.7 Thickened Edge Joints

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

3.9 REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS

3.9.1 General Criteria

Remove and replace or repair new pavement slabs that are broken, have spalled edges, or contain cracks, as specified hereinafter at no cost to the Government. Removal of partial slabs is not permitted. Do not spall more than 15.0 percent of each slab's edge. Slabs with spalls exceeding this quantity, regardless of spall size, must be sawn full depth to remove the spalled face, or 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. Ensure such cores are at least 150 mm 6 inch diameter, and drilled and backfilled with a well consolidated concrete mixture bonded to the walls of the hole with Type V, Grade 3 epoxy resin. Drilling of cores and refilling holes shall be performed by the Contractor at no expense to the Government.

3.9.2 Slabs with Cracks

Clean cracks that do not exceed 25 percent of the design thickness in depth and then pressure inject full depth with epoxy resin, Type IV, Grade 1. Remove slabs containing cracks deeper than 25 percent of the design thickness.

3.9.3 Repairing Spalls Along Joints

Repair details and materials must conform to UFC 3-270-03.

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.

****

Remove existing concrete pavement at locations indicated on the drawings. Prior to commencing pavement removal operations, the Contractor must inventory the pavement distresses (cracks, spalls, and corner breaks) along the pavement edge to remain. After pavement removal, the Contractor must again survey the remaining edge to quantify any damage caused by Contractor's removal operations. Both surveys must be performed by the Contractor, in the presence of the Contracting Officer. Make repairs as indicated and as specified herein. Carefully control all operations to

prevent damage to the concrete pavement and to the underlying material to remain in place. Make all saw cuts 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.
****

When existing concrete pavement is to be removed and adjacent concrete is to be left in place, first cut the joint between the removal area and adjoining pavement to stay in place full depth with a standard diamond-type concrete saw. Next, make a full depth saw cut 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. Make this saw cut with a wheel saw as specified in paragraph: Sawing Equipment. Remove all pavement to be removed beyond this last saw cut in accordance with the approved demolition work plan. Remove all pavement between this last saw cut and the joint line 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. Use suitable equipment to provide a truly vertical lift, and use safe lifting devices for attachment to the slab.

3.10.2 Edge Repair

Protect the edge of existing concrete pavement against which new pavement abuts from damage at all times. Remove areas which are damaged during construction 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.

3.10.2.1 Spall Repair

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, must be sawn full depth to remove the spalled face. Repair spalls along joints and along cracks where indicated and where directed. Use repair materials and procedures as previously specified in paragraph: Repairing Spalls Along Joints.

3.10.2.2 Underbreak and Underlying Material

Repair all underbreak by removal and repair of the damaged slabs in accordance with paragraph: Removal and Replacement of Full Slabs. Protect the underlying material adjacent to the edge of and under the existing pavement which is to remain in place from damage or disturbance during removal operations and until placement of new concrete, and shape as shown on the drawings or as directed. Keep sufficient underling material in place outside the joint line to completely prevent disturbance of material

under the pavement which is to remain in place. Carefuly remove any material under the portion of the concrete pavement to remain in place which is disturbed or loses its compaction and replace with concrete.

3.11 PAVEMENT PROTECTION

Protect the pavement against all damage prior to final acceptance by the Government. Do not pile aggregates, rubble, or other similar construction materials on airfield pavements. Block traffic 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, permit operation of the hauling equipment on the new pavement after the pavement has been cured for 7 days and the joints have been sealed or otherwise protected. Also, permit the subgrade planer, concrete paving and finishing machines, and similar equipment to ride upon the edges of previously constructed slabs when 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. Keep all new and existing pavement carrying construction traffic or equipment completely clean, and clean up spillage of concrete or other materials immediately upon occurrence.

3.12 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL

Sampling and testing shall be conducted on site at the expense of the Contractor, by a laboratory approved by the Contracting Officer. Supply samples as specified at the expense of the Contractor.

3.12.1 Sampling

3.12.1.1 Aggregates

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NOTE: Specify frequency of sampling aggregates during concrete placement; e.g., 1360 metric tons 1500 tons for coarse aggregates; 907 metric tons 1000 tons for fine aggregate.

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Sample fine and coarse aggregates at the batch plant. During concrete placement, sample coarse aggregates for each [_____] metric tons tons and fine aggregates for each [_____] metric tons tons. Sample in accordance with ASTM D 75.

3.12.1.2 Concrete

Obtain samples of plastic concrete in accordance with ASTM C 172. Quality control samples may be taken at the concrete batch plant; however, samples for verification of concrete strength and slump for submittal to the Government shall be taken in accordance with ASTM C 172 at the job-site as concrete is delivered. From each sample, mold the required number of beams and cylinders for each group of test specimens.

3.12.1.3 Sample Identification

Tag each for identification. Tag must contain the following information:

Contract No. [_____]

Sample No. [_____]

Date of Sample [_____]

Sample [_____]

Source [_____]

Intended Use [_____]

For Testing [_____]

3.12.2 Testing

3.12.2.1 Aggregate Tests

Perform gradation tests on each sample. Make other aggregate tests on initial source samples, and repeat tests whenever there is a change of source. During progress of concrete placement, perform gradation tests for fine and coarse aggregates. Include sieve analysis according to ASTM C 136 for each fractional size and gradation analysis of the combined material representing the aggregate part of the concrete mix.

3.12.2.2 Concrete Testing

a. Concrete Slump: Test consistency of concrete slump in accordance with ASTM C 143/C 143M. Determine consistency of concrete at the start of each day's concrete placement and for each group of test specimens.

b. Air Content: Determine air content at the start of concrete placement and for each group of test specimens. Record results with test specimens. Determine air content in accordance with ASTM C 231.

c. Surface Tests: Perform straightedge testing in accordance with paragraph: Surface Testing. Where defective areas of pavement are removed or replaced, the portion of the slab which remains in the pavement abutting the replacement slab shall have length and width not less than 3 m 10 feet from the nearest edge or joint.

d. Test for Pavement Thickness: Obtain 100 mm 4 inch diameter core samples to determine in-place thickness of concrete pavement. Obtain cores in accordance with ASTM C 42/C 42M. Remove cores at varying intervals but in no case less than two cores for each [850] [_____] square meters [1000] [_____] square yards. Repair core holes with non-shrink grout. Measure cores in accordance with ASTM C 174/C 174M. A tolerance in pavement thickness of plus or minus 13 mm 1/2 inch is permitted for individual core; however, the average thickness of cores must be at least [_____] mm inches. When determining the average, assign cores with a thickness of more than 13 mm 1/2 inch greater than specified, a thickness of the specified thickness plus 13 mm 1/2 inch. If measured pavement thickness is less than that shown by more than 13 mm 1/2 inch, remove deficient areas and replace with pavement of the specified strength, quality and thickness. When a core indicates unsatisfactory thickness, determine limits of the pavement to be removed and replaced as follows: Take one core for each slab of

lane in question in both directions from unsatisfactory core until satisfactory thickness is indicated; remove and replace pavement in each panel, for the full width of the lane, in which a core indicated unsatisfactory thickness. Include the following information in each of the reports of corings:

(1) Date concrete represented by core was placed

(2) Date core was taken

(3) Location of Core: Lane number, station number

(4) Thickness of core

(5) Condition of Core: Appearance, concrete texture, condition of bottom of core

(6) Disposition of Cores: In Contracting Officer or Contractor possession.

e. Flexural Strength: During progress of work verify flexural strength by testing beams made from concrete taken from the delivery vehicle at intervals specified herein. Mold and cure beams in accordance with ASTM C 31/C 31M. Perform tests in accordance with ASTM C 78. Mold at least eight beams each day from concrete placed that day. Select one group of four beams near the beginning of the work and a second group of four beams from the final third of concrete to be placed that day. Ensure an approved laboratory furnishes necessary labor, concrete and facilities for molding, handling, and storing the beams at the site of the work and testing beams. Perform tests at 28 days and 90 days. Earlier tests may be performed at the contractor's request, with no additional cost to the Government. Concrete must meet the following requirements:

(1) From each group of four beams, three beams tested at the end of 90 [ ] days must have an average flexural strength equal to or greater than the specified strength. Do not conside specimens obviously defective in the determination of the strengths.

(2) No individual beam of the three beams tested shall have a flexural strength less than 4.1 MPa 600 psi. Discard defective beams.

(3) Test one beam of the group at 28 [ ] days. If the ratio of the 28[ ]-day strength test to the specified 90-day strength is less than expected, make necessary adjustments for conformance.

(4) When a satisfactory relationship between 28[ ]-day and 90-day strengths has been established and approved by the Contracting Officer or his authorized representative, the 28[ ]-day test results may be used as an indication of the 90-day strengths. Remove or otherwise correct concrete which does not meet the specified strength, at the Contractor's expense, with corrective methods subject to the approval of the Contracting Officer or his authorized representative.

(5) If the 90 day strength test results do not meet the requirements specified herein, the contractor shall take a minimum

of three ASTM C 42/C 42M core samples from the in-place work represented by the low strength test results and test, at no cost to the Government, as long as compressive strength test results were performed at the same time as flexural strength tests and were submitted with the original mix design. Consider concrete represented by core tests structurally adequate if the average of the three cores is equal to at least 100 percent of the specified design strength. Remove concrete not meeting the strength criteria and provide new, acceptable concrete. Repair core holes with non-shrink grout. Match color and finish of adjacent concrete.

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NOTE: Use the text below for contracts which require concrete quantities of 1500 cubic meters 2000 cubic yards and more.
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f. Control Charts: Maintain control charts for concrete flexural strength in accordance with ACI 214R Appendix, except as otherwise modified herein. Post copies of charts at the job site. Indicate specified strength and average strength determined by the mix design. Each control chart must consist of the following plots:

(1) Test Results: At the same location, plot each individual test strength (the beam tested at 28 [ ] days and the average results of three beams tested at 90 days).

(2) Moving Average for Strength: Moving average of five consecutive tests ACI 214R

3.12.3 Reports

a. Report all results of tests or inspections conducted 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 reports of pertinent temperatures daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Confirm such reports of failures and the action taken in writing in the routine reports. The Contracting Officer has the right to examine all contractor quality control records.

b. Provide hardcopy documentation on Compact Disc (CD) for all preconstruction, production quality control, and acceptance testing for cementitious materials, aggregates, mineral and chemical admixtures, and fresh/hardened concrete. Cross-reference all production quality control and acceptance testing by pavement lot number and correlate to a placement map. The required format for the database will be provided by [_____].

-- End of Section --