
USACE / NAVFAC / AFCESA / NASA UFGS-32 01 28 (April 2008)

Preparing Activity: USACE Superseding
UFGS-32 01 28 (January 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2008

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SECTION 32 01 28

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04/08

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SECTION 32 01 28

PARTIAL-DEPTH PATCHING OF RIGID PAVEMENTS 04/08

NOTE: This guide specification covers the requirements for partial-depth patching of rigid pavements.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

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

Comments 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).

PART 1 GENERAL

NOTE: For full-depth patches or slab removal and replacement, use Section 32 13 11 or Section 32 13 13.03.

See UFC 3-270-03, "Concrete Crack and Partial-Depth Spall Repair" for drawings, details and illustrations.

1.1 UNIT PRICES

NOTE: When lump-sum payment is used, this paragraph will be deleted. If patching is a separate pay

item, the paragraph will be revised accordingly.

1.1.1 Measurement

1.1.1.1 Concrete

The quantity of concrete to be paid for will be the number of square **meters** **feet** placed in the completed and accepted patched areas.

1.1.1.2 Proprietary Cementitious Products

The quantity of proprietary cementitious product to be paid for will be the number of square **meters** **feet** placed in the completed and accepted patched areas.

1.1.2 Payment

1.1.2.1 Concrete

The quantity of concrete, measured as specified, will be paid for at the contract unit price. The unit price will include full compensation for furnishing labor; materials; and for performing work involved in patching the pavements as specified.

1.1.2.2 Proprietary Cementitious Products

The quantity of proprietary cementitious product, measured as specified, will be paid for at the contract unit price. The unit price will include full compensation for furnishing labor; materials; and for performing work involved in patching the pavements as specified.

1.2 REFERENCES

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

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

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

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

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

ASTM INTERNATIONAL (ASTM)

ASTM C 1059 (1999) Standard Specification for Latex
Agents for Bonding Fresh to Hardened
Concrete

ASTM C 1260 (2007) Standard Test Method for Potential
Alkali Reactivity of Aggregates
(Mortar-Bar Method)

ASTM C 136 (2006) Standard Test Method for Sieve
Analysis of Fine and Coarse Aggregates

ASTM C 143/C 143M (2008) Standard Test Method for Slump of
Hydraulic-Cement Concrete

ASTM C 150 (2007) Standard Specification for Portland
Cement

ASTM C 1581 (2004) Standard Test Method for
Determining Age at Cracking and Induced
Tensile Stress Characteristics of Mortar
and Concrete under Restrained Shrinkage

ASTM C 1602/C 1602M (2006) Standard Specification for Mixing
Water Used in Production of Hydraulic
Cement Concrete

ASTM C 171 (2007) Standard Specification for Sheet
Materials for Curing Concrete

ASTM C 192/C 192M (2007) Standard Practice for Making and
Curing Concrete Test Specimens in the
Laboratory

ASTM C 231 (2008) Standard Test Method for Air
Content of Freshly Mixed Concrete by the
Pressure Method

ASTM C 260 (2006) Standard Specification for
Air-Entraining Admixtures for Concrete

ASTM C 31/C 31M (2008) Standard Practice for Making and
Curing Concrete Test Specimens in the Field

ASTM C 33 (2007) Standard Specification for Concrete
Aggregates

ASTM C 39/C 39M (2005e1) Standard Test Method for
Compressive Strength of Cylindrical
Concrete Specimens

ASTM C 469	(2002e1) Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
ASTM C 531	(2000; R 2005) Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacing, and Polymer Concretes
ASTM C 666/C 666M	(2003) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C 685/C 685M	(2007) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 881/C 881M	(2002) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 882	(2005e1) Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear
ASTM D 75	(2003) Standard Practice for Sampling Aggregates

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete
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1.3 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

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,

Air Force, and NASA projects.

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

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

SD-03 Product Data

Mix Design[; G][; G, [_____]]

Proposed mix design, prior to placement. Indicate in the mix design the weight of each ingredient of the mixture. Do not place any concrete prior to approval of the proposed mix design. No deviation from the approved job-mix formula will be permitted without prior approval.

Proprietary Cementitious Products[; G][; G, [_____]]

Manufacturer's instructions for the proposed proprietary cementitious product. Include in the instructions details for substrate preparation, mixing, placing, finishing, curing and testing of the material. Include a minimum of three case histories documenting the use of the product in a similar freeze-thaw environment and airfield pavement condition.

SD-06 Test Reports

Test Results[; G][; G, [_____]]

Test results, within [24] [_____] hours of physical completion of laboratory testing. Do not place any material without prior approval from the Contracting Officer.

Volumetric mixer calibration and mixer efficiency test results. Results must be current within 6 months of concrete placement.

1.4 QUALITY ASSURANCE

1.4.1 Preconstruction Testing of Materials

NOTE: Guidance for preparation of criteria to be used in inspection of laboratory facilities is contained in ASTM E 329.

Perform sampling and testing using an approved commercial laboratory or by the Contractor subject, to approval. Should the Contractor elect to establish testing facilities, no work requiring testing will be permitted until the Contractor's facilities have been inspected and approved. The first laboratory inspection will be at the expense of the Government and

the cost of any subsequent inspection resulting from failure of the first inspection shall be at the expense of the Contractor. Such costs will be deducted from the total amount due the Contractor. All testing shall be performed at no additional cost to the Government.

1.4.2 Cement

Test cement as prescribed in the referenced specification under which it is furnished. Cement may be accepted on the basis of mill tests and the manufacturer's certification of compliance with the specification.

1.4.3 Aggregate

Take aggregate samples for laboratory testing in conformance with [ASTM D 75](#).

1.4.4 Proprietary Cementitious Products and Epoxy

At least 30 days before the material is used, submit certified copies of test results for the specific lots or batches to be used on the project. Test results shall be not more than 6 months old prior to use in the work.

1.4.5 Equipment Approval and Maintenance

Dependable and sufficient equipment that is appropriate and adequate to accomplish the work specified shall be assembled at the site of the work a sufficient time before the start of paving to permit thorough inspection, calibration of weighing and measuring devices, adjustment of parts, and the making of any repairs that may be required. The equipment shall be maintained in good working condition.

1.4.6 Weather Limitations

Do not place concrete when weather conditions detrimentally affect the quality of the finished product. No concrete shall be placed when the air temperature is below [5 degrees C](#) [40 degrees F](#) in the shade. When air temperature is likely to exceed [35 degrees C](#) [90 degrees F](#), the concrete shall have a temperature not exceeding [35 degrees C](#) [90 degrees F](#) when deposited, and the surface of such placed concrete shall be kept damp with a water fog until the approved curing medium is applied.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Cement

Cement may be furnished in bulk or in suitable bags used for packaging cements and stored in a manner to prevent absorption of moisture.

1.5.2 Aggregates

Handle and store aggregates in a manner to avoid breakage, segregation, or contamination by foreign materials.

1.5.3 Other Materials

Deliver epoxy-resin, chemical admixtures and proprietary cementitious products to the site in such manner as to avoid damage or loss. Provide storage areas in a windowless and weatherproof, but ventilated, insulated noncombustible building, with provision nearby for conditioning the material to [20 to 30 degrees C](#) [70 to 85 degrees F](#) for a period of 48 hours

prior to use. Keep the ambient temperature in the storage area no higher than 40 degrees C 100 degrees F.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Coarse Aggregate

2.1.1.1 Composition

Coarse aggregate shall consist of gravel, crushed gravel, crushed stone, or a combination thereof.

2.1.1.2 Quality

Aggregate, as delivered to the mixers, shall consist of clean, hard, unweathered, and uncoated particles. Dust and other coatings shall be removed from the coarse aggregates by adequate washing. Coarse aggregates shall meet the requirements of ASTM C 33, Class 4S for deleterious substances.

2.1.1.3 Particle Shape

Particles of the coarse aggregate shall be generally spherical or cubical in shape.

2.1.1.4 Grading

The maximum nominal size of the coarse aggregate shall be 13 mm 1/2 inch. The coarse aggregate shall be well graded within the limits specified, and when tested in accordance with ASTM C 136, shall conform to the following grading requirements as delivered to the batching hoppers:

Sieve designation U.S. Standard square mesh	Percentage by weight passing individual sieves 4.75 mm to 12.5 mm
19.0 mm	100
12.5 mm	90-100
9.5 mm	40-70
4.75 mm	0-15
2.36 mm	0-5
Sieve designation U.S. Standard square mesh	Percentage by weight passing individual sieves No. 4 to 1/2 inch
3/4 inch	100
1/2 inch	90-100
3/8 inch	40-70
No. 4	0-15
No. 8	0-5

2.1.1.5 Alkali Silica Reactivity

NOTE: For small quantity patching projects, include the first paragraph and require the use of non-reactive aggregates.

For large quantity patching projects, include Section 32 13 11 CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS and include the second paragraph cross-referencing ASR evaluation and mitigation testing.

[Coarse aggregates, to be used in all concrete, shall be evaluated and tested for alkali-silica reactivity in accordance with ASTM C 1260. Test results shall have a measured expansion equal to or less than 0.08 percent at 16 days. Should the test data indicate an expansion greater than 0.08 percent, the aggregate(s) shall be rejected.] [Evaluate coarse aggregates in accordance with Section 32 13 11, paragraph: Alkali-Silica Reactivity. Mitigation of reactive aggregates shall be in accordance with the referenced paragraph.]

2.1.2 Fine Aggregate

2.1.2.1 Composition

Provide fine aggregate consisting of either natural sand, manufactured sand, or a combination of natural and manufactured sand, and composed of clean, hard, durable particles.

2.1.2.2 Particle Shape and Quality

Particles of the fine aggregate shall be generally spherical or cubical in shape. Fine aggregate shall meet the requirements of ASTM C 33, Table 1 for deleterious substances.

2.1.2.3 Grading

Grading of the fine aggregate as delivered to the mixer shall conform to the following requirements when tested in accordance with ASTM C 136.

Sieve designation U.S. Standard square mesh	Percentage by weight, passing
9.5 mm	100
4.75 mm	95-100
2.36 mm	80-90
1.18 mm	60-80
0.60 mm	30-60
0.30 mm	12-30
0.15 mm	2-10
Sieve designation U.S. Standard square mesh	Percentage by weight, passing
3/8 inch	100
No. 4	95-100

Sieve designation U.S. Standard square mesh	Percentage by weight, passing
No. 8	80-90
No. 16	60-80
No. 30	30-60
No. 50	12-30
No. 100	2-10

In addition, the fine aggregate, as delivered to the mixer, shall have a fineness modulus of not less than 2.40 nor more than 2.90, when calculated in accordance with [ASTM C 136](#).

2.1.2.4 Alkali Silica Reactivity

Fine aggregates to be used in all concrete shall be evaluated and tested for alkali-silica reactivity using the procedures described for coarse aggregate.

2.1.3 Air-Entraining Admixture

Air-entraining admixture shall conform to [ASTM C 260](#).

2.1.4 Cement

NOTE: The use of either Type I, Type II, or Type III cement will be specified. Type III cement is a premium product and will be specified only when a short shutdown time is necessary.

Furnish portland cement conforming to [ASTM C 150](#), Type [____]. Low alkali cement shall be required if the proposed fine or coarse aggregates are found to have greater than 0.04 percent expansion when tested in accordance with paragraphs: Alkali Silica Reactivity.

2.1.5 Curing Materials

2.1.5.1 Burlap

Burlap shall conform to [AASHTO M 182](#).

2.1.5.2 Curing Compound

Membrane-forming curing compound shall be a pigmented type conforming to [COE CRD-C 300](#).

2.1.5.3 Waterproof Blanket Materials

Waterproof blanket materials shall conform to [ASTM C 171](#), Type optional, color white.

2.1.6 Bonding-Agents

2.1.6.1 Epoxy-Resin

Epoxy-resin shall be a two-component material formulated to meet the requirements of **ASTM C 881/C 881M**, Type III, grade and class as approved, for use in bond coat applications and as a component of epoxy-resin concrete or mortar.

2.1.6.2 Latex

Latex bonding agent shall meet the requirements of **ASTM C 1059**, Type II.

2.1.7 Joint-Sealing Materials

Joint-sealing materials shall be in accordance with Section 32 01 19.

2.1.8 Water

Water shall be clean, fresh, and free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances. Water approved by Public Health authorities for domestic consumption may be accepted for use without being tested. Water that is of questionable quality, in the opinion of the Contracting Officer, shall be tested in accordance with **ASTM C 1602/C 1602M**.

2.1.9 Proprietary Cementitious Products

**NOTE: The testing protocol for Proprietary
Cementitious Products is provided in the USAF draft
ETL, "Testing Protocol for Rigid Spall Repair
Materials."**

A proprietary cementitious product is defined as a rigid material in its hardened state with an elastic modulus greater than **6900 MPa 1,000,000 psi**. Maximum size of aggregate used to extend the product is **19 mm 3/4 inch**. The product shall be tested in accordance with the following test series. Each test shall be replicated on three specimens. All three results shall be reported for each test and the average value shall be used for comparison with the specification requirements. Report the curing conditions for each test type.

2.1.9.1 Compressive Strength

Cast **75 by 150 mm 3 by 6 inch** cylinder specimens in accordance with **ASTM C 192/C 192M** and test in accordance with **ASTM C 39/C 39M**, using bonded or unbonded caps, after 3 hours and 1 day curing period. A minimum compressive strength of **20.7 MPa 3500 psi** is required at 3 hours and 1 day of age.

2.1.9.2 Bond Strength

Cast **75 by 150 mm 3 by 6 inch** cylinder specimens and test in accordance with **ASTM C 882**. Cast the candidate material against a 30-degree wedge specimen consisting of the candidate material itself or an ordinary portland cement mixture. Test specimens, using bonded caps, after 1 day curing period. For a bond consisting of the candidate material bonded to

OPC mortar, a minimum bond strength of 3400 kPa 500 psi is required at 1 day of age. For a bond consisting of the candidate material bonded to itself, a minimum bond strength of 6900 kPa 1000 psi is required at 1 day of age.

2.1.9.3 Modulus of Elasticity

Cast 150 by 300 mm 6 by 12 inch cylinder specimens in accordance with ASTM C 192/C 192M and test in accordance with ASTM C 469, using bonded caps, after 3 day curing period. A maximum chord modulus of elasticity of 27,600 MPa 4,000,000 psi is required at 3 days of age.

2.1.9.4 Coefficient of Thermal Expansion

Cast 25 by 25 by 250 mm 1 by 1 by 10-inches prismatic bar specimens and test in accordance with ASTM C 531, after 3 days curing period. A maximum coefficient of $11.6 \text{ by } 10^{-6} \text{ mm per mm per degree C}$ $7 \text{ by } 10^{-6} \text{ inch per inch per degree F}$ is required at 3 days of age.

2.1.9.5 Shrinkage Potential

Cast 330 mm I.D. by 406 mm O.D. by 150 mm 13 inch I.D. by 16 inch O.D. by 6 inch tall restrained toroidal specimens and test in accordance with ASTM C 1581. Start measuring strain after completion of casting. A maximum of 40 microstrain is required at 14 days of age. No cracking is permitted at 28 days of age.

2.1.9.6 Freeze-Thaw Resistance

Cast prismatic specimens in accordance with ASTM C 192/C 192M and test in accordance with ASTM C 666/C 666M, Procedure A. Begin freeze-thaw testing after specimens have been immersed in saturated lime-water for 3 days. Report the Durability Factor (DF) and the number of cycles to failure.

2.2 MIX DESIGN

2.2.1 Portland Cement Concrete

The concrete mixtures shall be designed to produce concrete having an average compressive strength of 31 [_____] MPa 4500 [_____] psi at 28 days of age, determined in conformance with ASTM C 39/C 39M, using standard 150 by 300 mm 6 by 12 inch cylinder specimens. The concrete mixtures shall be designed to secure an air content by volume of [6] [_____] percent, plus or minus 1.5 percent, based on measurements made on concrete immediately after discharge from the mixer in conformance with ASTM C 231. Mix design studies and tests shall be made in accordance with ASTM C 39/C 39M and ASTM C 192/C 192M, and the test results submitted for approval. The maximum slump shall be 50 mm 2 inches when tested in accordance with ASTM C 143/C 143M.

2.2.2 Neat Cement Grout

Neat cement grout shall consist of Portland cement and water, thoroughly mixed to yield a thick, creamy mixture.

2.2.3 Epoxy-Resin Components

Mix epoxy-resin grout components in the proportions recommended by the manufacturer. Condition the components to 20 to 30 degrees C 70 to 85

degrees F for 48 hours prior to mixing. Mix the two epoxy components with a power-driven, explosion-proof stirring device in a metal or polyethylene container having a hemispherical bottom. The curing-agent component shall be added gradually to the epoxy-resin component with constant stirring until a uniform mixture is obtained. The rate of stirring shall be such that the entrained air is a minimum.

2.2.4 Proprietary Cementitious Products

Proprietary cementitious products shall be mixed in accordance with the manufacturer's recommendations. The use of admixtures or the addition of aggregate to extend the product shall be approved in writing by the manufacturer.

PART 3 EXECUTION

3.1 PREPARATION OF EXISTING PAVEMENT

3.1.1 Existing Surfaces

In the area to be patched, remove the surface of the existing concrete to a minimum depth of 50 mm 2 inches and to such additional depth where necessary to expose a surface of sound, unweathered concrete that is uncontaminated by oils, greases, or deicing salts or solutions. Make a vertical saw cut at least 50 mm 2 inches deep, a minimum of 25 mm 1 inch outside of the area to be repaired. Accomplish concrete removal in spalled areas with light, hand-held, high-frequency chipping hammers weighing not more than 14 kg 30 pounds or other approved hand tools. Do not use jack hammers weighing more than 14 kg 30 pounds and do not use pavement breaker devices mounted on or pulled by mobile equipment. The surface shall be thoroughly cleaned by sweeping and blowing with oil-free, compressed air. Prior to coating with the bonding coat, areas showing traces of oils or grease shall be cleaned by sandblasting.

3.1.2 Joints

Joint-sealing and expansion-joint materials shall be removed flush with the prepared surface, and, if on the pavement surface to be patched, shall be removed by sandblasting. The use of solvents will not be permitted. Care shall be used to prevent bonding of the adjacent concrete slabs at the location of the existing joints. Maintenance of these existing joints shall be accomplished by the use of fiberboard or other approved inserts of appropriate dimensions.

3.1.3 Bonding Coat

NOTE: In general a neat cement bonding coat is appropriate for all patch sizes. Epoxy-resin bond coats should be limited to patches less than 2 feet (600 mm) square. For proprietary cementitious patching products, prepare the substrate in accordance with the manufacturer's recommendations.

Prior to placing concrete, the previously prepared surfaces shall be washed with a high pressure water jet followed by an air jet to remove free water.

3.1.3.1 Neat Cement Grout

Coat the clean and dry surface, including sawed faces, with an approximate **2 mm 1/16 inch** thick coat of neat cement grout. Place the grout just prior to concrete placement and scrub with stiff bristle brushes to fill all voids and crevices in the spall cavity surface. Apply additional brush coats as needed to obtain the required thickness. The concrete patch material must be placed before the grout dries or sets. Remove dried or hardened grout by sandblasting and re-coat the cavity with fresh grout before placing concrete patch material.

3.1.3.2 Epoxy-Resin

Epoxy-resin bonding coat shall be limited to use on patches with a surface area of less than **600 mm 2 feet** square. Coat the clean and dry surface, including sawed faces, with a **0.02 to 0.04 mm 20 to 40 mil** thick film of the epoxy-resin grout. The epoxy-resin grout shall be placed in one application, just prior to concrete placement, with the use of mechanical combination, mixing and spraying equipment, or shall be applied in two coats with stiff brushes. The first brush coat shall be scrubbed into the concrete surface, followed by an additional brush coat to obtain the required thickness. When the brush method is used, the initial coat may be allowed to dry; however, the final coat shall be applied just prior to placement of the concrete.

3.1.3.3 Proprietary Cementitious Products

The type, use, and application of a bond coat shall be in accordance with the manufacturer's written instructions.

3.1.4 Patch Material Selection

The prepared cavity shall be filled with: Portland cement concrete or latex modified concrete for cavities more than **9400 cc 600 cubic inches** in volume after removal operations; portland cement mortar for cavities between **850 and 9400 cc 50 and 600 cubic inches**; and epoxy resin mortar or latex modified mortar for those cavities less than **850 cc 50 cubic inches** in size. Proprietary cementitious patching materials may be used, subject to approval by the Contracting Officer.

3.2 BATCHING, MIXING AND PROPORTIONING

3.2.1 Equipment

Provide adequate facilities for the accurate measurement and control of each of the materials entering the concrete. The Contracting Officer shall have free access to the batching and mixing plant at all times. Mixing equipment shall be capable of combining the aggregate, cement, admixture, and water into a uniform mixture and discharging this mixture without segregation. The use of volumetric batching and continuous mixing is acceptable, provided all operations are in accordance with **ASTM C 685/C 685M**. Submit the most recent calibration and mixer efficiency test results for approval. The results must be current within 6 months of concrete production.

3.2.2 Conveying

Convey concrete from mixer to repair area as rapidly as practicable by methods that will prevent segregation or loss of ingredients.

3.2.3 Facilities for Sampling

Provide suitable facilities for readily obtaining representative samples of aggregate and concrete for uniformity test purposes. Furnish the necessary platforms, tools, and equipment for obtaining samples.

3.2.4 Mix Proportions

The proportions of materials entering into the concrete mixtures shall be in accordance with the approved job-mix formula. Change the proportions whenever necessary to maintain the workability, strength, and standard of quality required, and to meet the varying conditions encountered during the construction. However, no changes will be made without prior approval.

3.2.5 Measurement of Mix Materials

Provide the equipment necessary to measure and control the amount of each material in each batch of concrete. Bulk cement shall be weighed, but cement in unopened bags, as packed by the manufacturer, may be used without weighing. If bagged cement is used, batches shall be proportioned so that fractional bags will not be required. One bag of portland cement will be considered as weighing 42 kg 94 pounds. Mixing water and air-entraining admixtures may be measured by volume or by weight. One liter gallon of water will be considered as weighing 3.78 kg 8.33 pounds.

3.2.6 Workability

Maintain the slump of the concrete at the lowest practicable value, not exceeding 50 mm 2 inches when tested in accordance with ASTM C 143/C 143M.

3.3 PLACING

3.3.1 Portland Cement Concrete

Place concrete within 45 minutes from the time all ingredients are charged into the mixing drum, before the concrete has obtained its initial set, and while the bonding coat is tacky. The temperature of the concrete, as deposited in the form, shall be not less than 5 degrees C 40 degrees F nor more than 35 degrees C 90 degrees F. Deposit concrete in such manner as to require a minimum of rehandling, and to least disturb the bonding coat. The placing of concrete shall be rapid and continuous for each area. Workmen shall not walk on the bonding-course surface or in the concrete during placing and finishing operations. The concrete shall be thoroughly consolidated by tamping or by means of suitable vibrating equipment.

3.3.2 Epoxy-Resin Concrete and Mortar

Epoxy-resin bonding coat shall be limited to use on patches with a surface area of less than 600 mm 2 feet square. Place the epoxy resin materials in layers not over 50 mm 2 inches thick. The time interval between placement of additional layers shall be such that the temperature of the epoxy resin material does not exceed 60 degrees C 140 degrees F at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or mortar. Remove any repair material on the surrounding surfaces of the existing concrete before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints. The

reservoir shall be thoroughly cleaned and then sealed with the sealer specified for the joints. [In lieu of sawing, spalls not adjacent to joints and popouts, both less than 150 mm 6 inches in maximum dimension, may be prepared by drilling a core 50 mm 2 inches in diameter greater than the size of the defect, centered over the defect, and 50 mm 2 inches deep or 13 mm 1/2 inch into sound concrete, whichever is greater. The core hole shall be repaired as specified above for other spalls.]

3.3.3 Proprietary Cementitious Products

Perform placing, consolidating, finishing, and curing operations in accordance with the manufacturer's written instructions.

3.4 FIELD TEST SPECIMENS

3.4.1 General Requirements

Furnish concrete samples, taken in the field and tested to determine the slump, air content, and strength of the concrete. Make test cylinders for determining conformance with the strength requirements of these specifications and, when required, for determining the time at which pavements may be placed in service. The air content shall be determined in conformance with ASTM C 231. Test cylinders shall be molded and cured in conformance with ASTM C 31/C 31M and as specified below. Furnish all materials, labor, and facilities required for molding, curing, and protecting test cylinders at the site and under the supervision of the Contracting Officer. Curing facilities for test beams shall include furnishing and operating water tanks equipped with temperature-control devices that will automatically maintain the temperature of the water at 23 degrees C 73 degrees F plus or minus 3 degrees C 5 degrees F. Also furnish and maintain at the site, boxes or other facilities suitable for storing the specimens while in the mold at a temperature of 23 degrees C 73 degrees F plus or minus 6 degrees C 10 degrees F. Tests of the fresh concrete and of the hardened concrete cylinders shall be made by and at the expense of the Contractor. Tests of Proprietary Cementitious Products shall be in accordance with the manufacturer's written instructions.

3.4.2 Specimens for Strength Tests

Make cylinders for each shift of placed concrete. Each group of test cylinders shall be molded from the same batch of concrete, and shall consist of a sufficient number of specimens to provide two compressive-strength tests at each test age. One group of specimens shall be made during the first half of each shift, and the other during the last portion of the shift. However, at the start of paving operations and each time the aggregate source, aggregate characteristics, or mix design is changed, one additional set of test cylinders shall be made.

3.5 FINISHING

Start finishing operations immediately after placement of the concrete. The finished surfaces of patched areas shall have a surface texture approximating that of the adjacent undisturbed pavements.

3.6 CURING

NOTE: A minimum curing time of 7 days will be required when Type I or Type II cements are used. A

**minimum curing period of 3 days will be specified
for Type III cement.**

Cure the concrete by protection against loss of moisture and rapid temperature changes for a period of not less than [_____] days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. Provide all equipment needed for adequate curing and protection of the concrete on hand and ready to install before actual concrete placement begins. Cure proprietary cementitious products in accordance with manufacturer's recommendations. Failure to comply with curing requirements will be cause for immediate suspension of concreting operations.

3.6.1 Moist Curing

Moist-cure all portland cement concrete patches for the first 24-hours after finishing. Immediately after the finishing operations have been completed and the concrete has set sufficiently to prevent marring the surface, the entire surface of the newly laid concrete shall be covered with approved wetted burlap that shall be kept wet for a period of not less than 24 hours. The surface of the newly laid concrete shall be kept moist until the burlap coverings are in place. Ensure that moist curing is continuous 24 hours per day and that the entire surface is wet, by having an approved work system. Curing of the concrete shall be continued for the duration of the required curing period by this method or one of the methods specified below.

3.6.2 Waterproof-Paper Blankets or Impermeable Sheets

Immediately after removing the covering used for initial curing, the exposed concrete surfaces shall be moistened with a fine spray of water and then covered with waterproof-paper blankets, polyethylene-coated-burlap blankets, or impermeable sheets. Burlap of polyethylene-coated burlap shall be saturated with water before placing. Sheets shall be placed with the light-colored side up. Sheets shall overlap not less than 300 mm 12 inches with edges taped or secured to form a completely closed joint. Coverings shall be weighted down to prevent displacement or billowing from winds. Tears or holes appearing during the curing period shall be immediately repaired by patching.

3.6.3 Membrane-Forming Curing Compound

Membrane-forming curing compound shall be applied immediately to exposed concrete surfaces after removing burlap coverings. The curing compound shall be applied with an overlapping coverage that will give a two-coat application at a coverage of not more than 20 square m/L 200 square feet per gallon for both coats. When application is made by hand-operated sprayers, the second coat shall be applied in a direction approximately at right angles to the first coat. Concrete shall be properly cured at joints, but no curing compound shall enter joints that are to be sealed with joint-sealing compounds. The compound shall form a uniform, continuous, cohesive film that will not check, crack, or peel, and that will be free from pinholes and other imperfections. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed at the coverage specified above and at no additional cost to the Government. Areas covered with curing compound that are damaged by pedestrian and vehicular traffic or by subsequent construction operations within the specified curing period shall be

resprayed at no additional cost to the Government.

3.7 FINISH TOLERANCE

The finished surfaces of patched areas shall meet the grade of the adjoining pavements and shall not deviate more than 3 mm 1/8 inch from a true plan surface within the patched area.

3.8 PAVEMENT PROTECTION

Protect the patched areas against damage prior to final acceptance of the work by the Government. Exclude traffic from the patched areas by erecting and maintaining barricades and signs until the completion of the curing period of the concrete.

3.9 JOINTS

Joints shall conform in detail and be in alignment with the existing joints. After curing of the concrete, the joints shall be prepared and sealed in accordance with Section 32 01 19.

-- End of Section --