
USACE / NAVFAC / AFCEA UFGS-02752 (August 2004)

Preparing Activity: NAVFAC Superseding
UFGS-02752N (September 2001)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMLR dated 22 December 2004

Latest change indicated by CHG tags

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DIVISION 02 - SITE CONSTRUCTION

SECTION 02752

PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES

08/04

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SECTION 02752

PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES 08/04

NOTE: This guide specification covers the requirements for small portland cement concrete paving jobs such as roads, streets, sidewalks, and parking lots.

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).

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.

NOTE: The extent and location of the work to be accomplished should be indicated on the project drawings, or included in the project specifications. Precast structural concrete and portland cement pavements for airports are not included in this specifications.

PART 1 GENERAL

1.1 REFERENCES

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.**

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 301	(1999) Specifications for Structural Concrete for Buildings
ACI 305R	(1999) Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting

ASTM INTERNATIONAL (ASTM)

ASTM A 184/A 184M	(2001) Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A 615/A 615M	(2004b) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 617/A 617M	(1996a) Axle-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 775/A 775M	(2001) Epoxy-Coated Reinforcing Steel Bars
ASTM C 1077	(2003a) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1260	(2001) Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C 143/C 143M	(2003) Slump of Hydraulic Cement Concrete
ASTM C 150	(2004a) Portland Cement
ASTM C 171	(2003) Sheet Materials for Curing Concrete
ASTM C 172	(2004) Sampling Freshly Mixed Concrete
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 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 494/C 494M	(2004) Chemical Admixtures for Concrete
ASTM C 59/C 59M5	(2000; Rev A) Blended Hydraulic Cements
ASTM C 59/C 59M5M	(1997) Blended Hydraulic Cements (Metric)
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 94/C 94M	(2004a) Ready-Mixed Concrete
ASTM C 989	(2004) Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS L-C-530	(Rev C) Coating, Pipe, Thermoplastic Resin
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1.2 SUBMITTALS

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.

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

Curing materials

Admixtures

Dowel

[Reinforcement]

Submit a complete list of materials including type, brand and applicable reference specifications.

SD-05 Design Data

Concrete mix design

Thirty days minimum prior to concrete placement, submit a mix design, with applicable tests, for each strength and type of concrete for approval. Submit a complete list of materials including type; brand; source and amount of cement, fly ash, slag, and admixtures; and applicable reference specifications. Provide mix proportion data using at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required. Submittal shall clearly indicate where each mix design will be used when more than one mix design is submitted. Obtain acknowledgement of approvals prior to concrete placement. Submit a new mix design for each material source change.

SD-06 Test Reports

Aggregate tests

Concrete slump tests

Air content tests

Flexural strength tests

SD-07 Certificates

Ready-mixed concrete plant

Batch tickets

Cementitious materials

1.3 DELIVERY, STORAGE, AND HANDLING

ASTM C 94/C 94M.

1.4 QUALITY ASSURANCE

1.4.1 Ready-mixed Concrete Plant Certification

Provide documentation that the ready-mix plant is certified by the National Ready-Mix Concrete Association (NRMCA).

1.4.2 Required Information

Submit copies of laboratory test reports showing that the mix has been successfully tested to produce concrete with the properties specified and that mix will be suitable for the job conditions. The laboratory test reports shall include mill test and all other test for cementitious materials, aggregates, and admixtures. Provide maximum nominal aggregate size, gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Test reports shall be submitted along with the concrete mix design. Sampling and testing of materials, concrete mix design, sampling and testing in the field shall be performed by a commercial testing laboratory which conforms to ASTM C 1077. The laboratory shall be approved in writing by the Government.

1.4.3 Batch Tickets

ASTM C 94/C 94M. Submit mandatory batch ticket information for each load of ready-mixed concrete.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

NOTE: ASTM C 59/C 59M5MASTM C 59/C 59M5 covers four kinds of blended hydraulic cements. The four types are as follows:

1. Portland Blast - Furnace Slag Cement (Type IS).
2. Portland - Pozzolan Cement (Types IP and P).
3. Slag Cement (Type S).
4. Pozzolan - Modified Portland Cement (Type I (PM)).

For sulfate resistance consider using types IS (MS) or IP (MS), II, and V.

Types IS-A, IP-A, PA, SA, and PM-A are air-entrained cements but should not be specified because of inability to control air content and lack of

uniformity.

Type S cement should not be used when special characteristics (including control of alkali-silica reaction problems) are desired.

2.1.1.1 Cement

ASTM C 150, Type I or II [III, for high early concrete] [or V] [or ASTM C 59/C 59M5M ASTM C 59/C 59M5, Type IS, IP, or P] with maximum alkali content of 0.60%. Cement certificate shall include test results in accordance with ASTM C 150, including equivalent alkalies indicated in the Supplementary Optional Chemical Requirements.

NOTE: A maximum alkali content of 0.40% is more desirable and should be used where available, but is not required.

2.1.1.2 Fly Ash and Pozzolan

NOTE: Fly ash, pozzolan, and slag cement may produce uneven discoloration of the concrete during the early stages of construction, depending upon the type of curing provided. Fly ash or pozzolan meeting the specified test results, which are more stringent than ASTM C 618, should provide acceptable end results.

ASTM C 618, Type F, except that the maximum allowable loss on ignition shall be 6%, maximum available alkalies content shall be 1.5%, and maximum calcium oxide (CaO) content 8%. Fly ash certificates shall include test results in accordance with ASTM C 618, including available alkalies indicated in the Supplementary Optional Chemical Requirements.

NOTE: A maximum calcium oxide content of 2% is more desirable but not required.

2.1.1.3 Slag

ASTM C 989, Ground Granulated Blast Furnace Slag (GGBFS), Grade 100 or 120. Certificates shall include test results in accordance with ASTM C 989.

NOTE: GGBFS Grade 120 is more desirable but Grade 100 is allowed.

2.1.2 Water

ASTM C 94/C 94M, fresh, clean, and potable.

2.1.3 Aggregate

2.1.3.1 Alkali Reactivity Test

NOTE: While not wholly conclusive, petrographic examination (ASTM C 295) and the Chemical Test Method (ASTM C 28/c 28M9) are valuable indicators. However, chemical test results may not be correct for aggregates containing carbonates of calcium, magnesium or ferrous iron, such as calcite, dolomite, magnesite or siderite; or silicates of magnesium such as serpentine. The Concrete Prism Test (ASTM C 1293) is also a valuable indicator. However, none of the methods above constitutes a substitute for the modified ASTM C 1260.

NOTE: The most important rocks and mineral known to be deleteriously reactive with the alkalis in Portland cement are listed in ASTM C 33 (and ASTM C 294). However, this list is not inclusive, and particles having a glassy or micro-crystalline structure should be considered suspect. Reactive aggregates are widespread in the United States, being especially common in the western half and southeastern portions. However, generalizations concerning area distribution of reactive aggregates should not be relied upon for important work. Contract documents for important concrete projects should include provisions for preventing such aggregate being used, if possible, or requiring their use exclusively with low-alkali cements, suitable blended cements, or pozzolanic admixtures as available and as required to avoid deleterious effects on the concrete.

Fine and Coarse aggregates to be used in all concrete shall be evaluated and tested by the Contractor for alkali-aggregate reactivity in accordance with ASTM C 1260. The coarse and fine aggregates shall be evaluated in a combination which matches the contractors' proposed mix design (including Class F fly ash or GGBF slag), utilizing the modified version of ASTM C 1260. Test results of the combination shall have a measured expansion of less than 0.08 percent at 16 days. Should the test data indicate an expansion of greater than 0.08%, the aggregate(s) shall be rejected and the contractor shall submit new aggregate sources for retesting or may submit additional test results incorporating Lithium Nitrate for consideration.

ASTM C 1260 shall be modified as follows to include one of the following options:

- a. Utilize the contractor's proposed low alkali Portland cement and Class F fly ash in combination for the test proportioning. The laboratory shall use the contractor's proposed percentage of cement and fly ash.
- b. Utilize the contractor's proposed low alkali Portland cement and

ground granulated blast furnace (GGBF) slag in combination for the test proportioning. The laboratory shall use the contractor's proposed percentage of cement and GGBF.

- c. Utilize the contractor's proposed low alkali Portland cement and Class F fly ash and ground granulated blast furnace (GGBF) slag in combination for the test proportioning. The laboratory shall use the contractor's proposed percentage of cement, fly ash and GGBF.

NOTE: It is recommended that the coarse and fine aggregates also be evaluated separately, in accordance with the original ASTM C 1260, to ascertain the specific reactivity of each aggregate.

2.1.3.2 Fine Aggregates

ASTM C 33.

2.1.3.3 Coarse Aggregates

NOTE: Use the maximum nominal size aggregate. No. 67 20 mm to No. 4.75 mm sieve 3/4 inch to No. 4 sieve or No. 57 25.0 mm to 4.75 mm sieve one inch to No. 4 sieve are typical. Use the largest aggregate size which will accomodate rebar spacing and form spacing as per ACI. Allow No. 467 37.5 mm to 4.75 mm 1 1/2 inch to No. 4 sieve when ACI clearance requirements are meet, especially for concrete slabs and pavements without rebar. Maximum aggregate size should not exceed:

1. 1/5 the dimension of nonreinforced members.

2. 3/4 the clear spacing between reinforcing bars or between reinforcing bars and forms.

3. 1/3 the depth of nonreinforced slabs on the ground.

ASTM C 33.

2.1.4 Admixtures

ASTM C 494/C 494M: Type A, water reducing; Type B, retarding; Type C, accelerating; Type D, water-reducing and retarding; and Type E, water-reducing and accelerating admixture. Do not use calcium chloride admixtures. Where not shown or specified, the use of admixtures is subject to written approval of the Contracting Officer.

ASTM C 260: Air-entraining.

2.1.5 Reinforcement

2.1.5.1 Dowel Bars

Bars shall conform to ASTM A 615/A 615M, [Grade 300] [Grade 420] [Grade 40] [Grade 60] for plain billet-steel bars of the size and length indicated. Remove all burrs and projections from the bars.

2.1.5.2 Coated Dowel Bars

Bars shall conform to ASTM A 615/A 615M, [Grade 300] [Grade 420] [Grade 40] [Grade 60] for plain billet-steel bars of the size and length indicated. Remove all burrs or projections from the dowel bars. Coating system shall conform to FS L-C-530, Type 2. Coat the bars with a double coat system or an epoxy coating system for resistance to penetration of oil and salt solutions. The systems shall be in accordance with manufacturer's recommendation for coatings which are not bondable to concrete. Bond the coating to the dowel bar to resist laps or folds during movement of the joint. Coating thickness shall be 0.175 mm 7 mils minimum and 0.5 mm 20 mils maximum.

2.1.5.3 Tie Bars

Bars shall be billet or axle steel deformed bars and conform to ASTM A 615/A 615M or ASTM A 617/A 617M [Grade 300] [Grade 420] [Grade 40] [Grade 60]. [Epoxy coated in accordance with ASTM A 775/A 775M.]

[2.1.5.4 Reinforcement

Deformed steel bar mats shall conform to ASTM A 184/A 184M. Bar reinforcement shall conform to [ASTM A 615/A 615M] [ASTM A 617/A 617M], [Grade 300] [Grade 420] [Grade 40] [Grade 60].

]2.1.6 Curing Materials

2.1.6.1 White-Burlap-Polyethylene Sheet

ASTM C 171, 0.10 mm0.004 inch thick white opaque polyethylene bonded to 0.31 kg per meter10 oz/linear yard (1.0 meter) (40 inch) wide burlap.

2.1.6.2 Liquid Membrane-Forming Compound

ASTM C 309, white pigmented, Type 2, Class B, free of paraffin or petroleum.

[2.1.6.3 Liquid Chemical Sealer-Hardener Compound

Compound shall be magnesium fluosilicate which when mixed with water seals and hardens the surface of the concrete. Do not use on exterior slabs exposed to freezing conditions. Compound shall not reduce the adhesion of resilient flooring, tile, paint, roofing, waterproofing, or other material applied to concrete.

]2.1.7 Joint Fillers and Sealants

Provide as specified in Section [02760 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS] [02762 COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS]. [New joints shall match existing alignment.]

2.2 CONTRACTOR-FURNISHED MIX DESIGN

NOTE: The 3.79 MPa 550 psi flexural strength specified in paragraph entitled "Flexural Tests" is based on 4.48 MPa 650 psi flexural strength, 35 MPa 5,000 psi compressive strength, specified in paragraph entitled "CONTRACTOR-FURNISHED MIX DESIGN." If other flexural strength is specified in paragraph entitled "CONTRACTOR-FURNISHED MIX DESIGN," modify paragraph entitled "Flexural Tests." See Section 02751, "Reinforced Cement Concrete Pavement for Roads and Airfields" for further information.

NOTE: This specification is based on a flexural strength basis. For small jobs 75 cubic meters or less 100 cubic yards or less, compressive strength may be used. In that case modify these paragraphs to reflect a compressive strength basis.

NOTE: Allowable Air Content: Select 5 percent air content for maximum aggregate size of 37.5 or 50 mm 1 1/2 or 2 inches, and 6 percent air content for maximum aggregate size for 19 or 25 mm 3/4 or one inch.

NOTE: Minimum Cement Factor: The cement required to produce concrete strength of 4.48 MPa 650 psi at 28 days is generally sufficient to provide durable concrete and resistance to surface abrasion. In localities of substandard aggregates or when concrete is machine finished without vibration or finished with hand tools, a minimum cement factor should be specified. Specifying a minimum cement factor will not necessarily provide the specified flexural strength and additional cement may be required. The actual amount of cement required to obtain the required strength is decided by the Contractor based on mix designs for local aggregates and type of equipment and methods to be used in the field production of the concrete. Select a minimum cement factor to compensate for poor quality aggregates, seawater exposure, and for sites of difficult concrete placement conditions. Guidance for minimum cement contents for suitability, durability and workability of concrete is frequently given in the State Standard Specifications.

Contractor-furnished mix design concrete shall be designed in accordance with ACI 211.1 except as modified herein, and the mix design shall be as specified herein under paragraph entitled "Submittals." The concrete shall have a minimum flexural strength of [4.48] [_____] MPa [650] [_____] pounds per square inch at 90 days. The concrete may be air entrained. If air entrainment is used the air content shall be [5.0 plus or minus 1.5 percent] [6.0 plus or minus 1.5 percent]. Maximum size aggregate for slip

forming shall be 38 mm1.5 inches. The minimum cementitious factor is 335 kg per cubic meter564 lbs per cubic yard and slump shall be 25 mm to 75 mm1 to 3 inches (or less when slip form is used.

If the cementitious material is not sufficient to produce concrete of the flexural strength required it shall be increased as necessary, without additional compensation under the contract. The cementitious factor shall be calculated using cement, Class F fly ash, and or GGBF slag. The mix shall use a cement replacement (by weight) of 25%-35% Class F fly ash, or 40%-50% GGBF slag, or a combination of the two. In the combination, each 5% of Class F fly ash shall be replaced by 8% GGBF slag.

PART 3 EXECUTION

3.1 FORMS

3.1.1 Construction

Construct forms to be removeable without damaging the concrete.

3.1.2 Coating

Before placing the concrete, coat the contact surfaces of forms [except existing pavement sections where bonding is required,] with a non-staining mineral oil, non-staining form coating compound, or two coats of nitro-cellulose lacquer. [When using existing pavement as a form, clean existing concrete and then coat with asphalt emulsion bondbreaker before concrete is placed.]

3.1.3 Grade and Alignment

Check and correct grade elevations and alignment of the forms immediately before placing the concrete.

3.2 REINFORCEMENT

3.2.1 Dowel Bars

NOTE: For projects which require dowel bars or coated dowel bars, show location, size, and tolerances on the drawings.

Install bars accurately aligned, vertically and horizontally, at indicated locations and to the dimensions and tolerances indicated. Before installation thoroughly grease the sliding portion of each dowel. Dowels must remain in position during concrete placement and curing.

3.2.2 Coated Dowel Bars

Install bars, accurately aligned vertically and horizontally, at indicated locations and to the dimensions and tolerances indicated. Reject coatings which are perforated, cracked or otherwise damaged. While handling avoid scuffing or gouging of the coatings.

3.2.3 Tie Bars

NOTE: When tie bars are required in the contract, indicate location on drawings. Show bar size and spacing required and method of support.

Install bars, accurately aligned horizontally and vertically, at indicated locations. [For slipform construction, insert bent tie bars by hand or other approved means.]

3.2.4 Setting Slab Reinforcement

NOTE: For contracts which require reinforcing steel, specify the type, size and material of reinforcement. Edit paragraph to specify method of placement as appropriate for thickness of the concrete.

Reinforcement shall be positioned on suitable chairs prior to concrete placement. At expansion, contraction and construction joints, place the reinforcement as indicated. Reinforcement, when placed in concrete, shall be free of mud, oil, scale or other foreign materials. Place reinforcement accurately and wire securely. The laps at splices shall be 300 mm 12 inches minimum and the distances from ends and sides of slabs and joints shall be as indicated.

3.3 MEASURING, MIXING, CONVEYING, AND PLACING CONCRETE

3.3.1 Measuring

ASTM C 94/C 94M.

3.3.2 Mixing

ASTM C 94/C 94M, except as modified herein. Begin mixing within 30 minutes after cement has been added to aggregates. When the air temperature is greater than 29.4 degrees C 85 degrees F, reduce mixing time and place concrete within 60 minutes. Additional water may be added to bring slump within required limits as specified in Section 11.7 of ASTM C 94/C 94M, provided that the specified water-cement ratio is not exceeded.

3.3.3 Conveying

ASTM C 94/C 94M.

3.3.4 Placing

Follow guidance of ACI 301, except as modified herein. Do not exceed a free vertical drop of 0.90 m 3 feet from the point of discharge. Place concrete continuously at a uniform rate, with minimum amount of segregation, without damage to the grade and without unscheduled stops except for equipment failure or other emergencies. If this occurs within 3 m10 feet of a previously placed expansion joint, remove concrete back to joint, repair any damage to grade, install a construction joint and continue placing concrete only after cause of the stop has been corrected.

3.3.5 Vibration

Immediately after spreading concrete, consolidate concrete with internal type vibrating equipment along the boundaries of all slabs regardless of slab thickness, and interior of all concrete slabs 150 mm 6 inches or more in thickness. Limit duration of vibration to that necessary to produce consolidation of concrete. Excessive vibration will not be permitted. Vibrators shall not be operated in concrete at one location for more than 15 seconds. At the option of the Contractor, vibrating equipment of a type approved by the Contracting Officer may be used to consolidate concrete in unreinforced pavement slabs less than 150 mm 6 inches thick.

3.3.5.1 Vibrating Equipment

Operate equipment, except hand-manipulated equipment, ahead of the finishing machine. Select the number of vibrating units and power of each unit to properly consolidate the concrete. Mount units on a frame that is capable of vertical movement and, when necessary, radial movement, so vibrators may be operated at any desired depth within the slab or be completely withdrawn from the concrete. Clear distance between frame-mounted vibrating units that have spuds that extend into the slab at intervals across the paving lane shall not exceed 750 mm 30 inches. Distance between end of vibrating tube and side form shall not exceed 50 mm 2 inches. For pavements less than 250 mm 10 inches thick, operate vibrators at mid-depth parallel with or at a slight angle to the subbase. For thicker pavements, angle vibrators toward the vertical, with vibrator tip preferably about 50 mm 2 inches from subbase, and top of vibrator a few mm inches below pavement surface. Vibrators may be pneumatic, gas driven, or electric, and shall be operated at frequencies within the concrete of not less than 8,000 vibrations per minute. Amplitude of vibration shall be such that noticeable vibrations occur at 450 mm 1.5 foot radius when the vibrator is inserted in the concrete to the depth specified.

3.3.6 Cold Weather

NOTE: Calcium chloride accelerators should not be permitted for reinforced concrete and in concrete in contact with aluminum or other non-ferrous materials.

Except with authorization, do not place concrete when ambient temperature is below 5 degrees C 40 degrees F or when concrete is likely to be subjected to freezing temperatures within 24 hours. When authorized, when concrete is likely to be subjected to freezing within 24 hours after placing, heat concrete materials so that temperature of concrete when deposited is between 18 and 27 degrees C 65 and 80 degrees F. Methods of heating materials are subject to approval of the Contracting Officer. Do not heat mixing water above 74 degrees C 165 degrees F. Remove lumps of frozen material and ice from aggregates before placing aggregates in mixer. Follow practices found in ACI 306.1.

3.3.7 Hot Weather

Maintain required concrete temperature in accordance with Figure 2.1.5 in ACI 305R to prevent evaporation rate from exceeding 0.98 kg of water per square meter 0.2 pound of water per square foot of exposed concrete per hour. Cool ingredients before mixing or use other suitable means to control concrete temperature and prevent rapid drying of newly placed

concrete. After placement, use fog spray, apply monomolecular film, or use other suitable means to reduce the evaporation rate. Start curing when surface of fresh concrete is sufficiently hard to permit curing without damage. Cool underlying material by sprinkling lightly with water before placing concrete. Follow practices found in ACI 305R.

3.4 PAVING

Pavement shall be constructed with paving and finishing equipment utilizing [fixed forms] [slipforms].

3.4.1 Consolidation

The paver vibrators shall be inserted into the concrete not closer to the underlying material than 50 mm. 2 inches. The vibrators or any tamping units in front of the paver shall be automatically controlled so that they shall be stopped immediately as forward motion ceases. Excessive vibration shall not be permitted. Concrete in small, odd-shaped slabs or in locations inaccessible to the paver mounted vibration equipment shall be vibrated with a hand-operated immersion vibrator. Vibrators shall not be used to transport or spread the concrete.

3.4.2 Operation

When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provisions shall be made to prevent damage to the previously constructed pavement, including keeping the existing pavement surface free of any debris, and placing rubber mats beneath the paver tracks. Transversely oscillating screeds and extrusion plates shall overlap the existing pavement the minimum possible, but in no case more than 200 mm. 8 inches.

3.4.3 Required Results

The paver-finisher shall be operated to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. The paver-finishing operation shall produce a surface finish free of irregularities, tears, voids of any kind, and any other discontinuities. It shall produce only a very minimum of paste at the surface. Multiple passes of the paver-finisher shall not be permitted. The equipment and its operation shall produce a finished surface requiring no hand finishing, other than the use of cutting straightedges, except in very infrequent instances. No water, other than true fog sprays (mist), shall be applied to the concrete surface during paving and finishing.

3.4.4 Fixed Form Paving

**NOTE: Delete bracketed sentences on overlay
pavements if not applicable.**

Forms shall be steel, except that wood forms may be used for curves having a radius of 45 m 150 feet or less, and for fillets. Forms may be built up with metal or wood, added only to the base, to provide an increase in depth of not more than 25 percent. The base width of the form shall be not less than eight-tenths of the vertical height of the form, except that forms 200 mm 8 inches or less in vertical height shall have a base width not less than the vertical height of the form. Wood forms for curves and fillets

shall be adequate in strength and rigidly braced. Forms shall be set on firm material cut true to grade so that each form section when placed will be firmly in contact with the underlying layer for its entire base. Forms shall not be set on blocks or on built-up spots of underlying material. [Forms for overlay pavements and for other locations where forms must be set on existing pavements shall be held securely in place with stakes or by other approved methods. Holes in existing pavements for form stakes shall be carefully drilled without cracking or spalling the existing pavement. Prior to setting forms for paving operations, the Contractor shall demonstrate the proposed form setting procedures at an approved location and shall not proceed further until the proposed method is approved.] Forms shall remain in place at least 12 hours after the concrete has been placed. Forms shall be removed without injuring the concrete.

3.4.5 Slipform Paving

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

The slipform paver shall shape the concrete to the specified and indicated cross section in one pass, and shall finish the surface and edges so that only a very minimum amount of hand finishing is required. Dowels shall not be installed by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete. [If a keyway is required, a 0.45 to 0.55 mm 26 gauge thick metal keyway liner shall be installed as the keyway is extruded. [The keyway liner shall be protected and shall remain in place and become part of the joint.]]

3.4.6 Placing Reinforcing Steel

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

Reinforcement shall be positioned on suitable chairs securely fastened to the subgrade prior to concrete placement. [If reinforcing for Continuously Reinforced Concrete Pavement (CRCP) is required, the entire operating procedure and equipment proposed shall be submitted for approval at least 30 days prior to proposed start of paving.]

3.4.7 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.

Dowels shall be installed with alignment not greater than 1 mm per 100 mm. 1/8 inch per ft. Except as otherwise specified below, location of dowels shall be within a horizontal tolerance of plus or minus 15 mm 5/8 inch and a

vertical tolerance of plus or minus 5 mm. 3/16 inch. The portion of each dowel intended to move within the concrete or expansion cap shall be painted with one coat of rust inhibiting primer paint, and then oiled just prior to placement. [Dowels] [and tie bars] in joints shall be omitted when the center of the [dowel] [tie bar] is located within a horizontal distance from an intersecting joint equal to or less than one-fourth of the slab thickness.

3.4.7.1 Contraction Joints

[Dowels] [and] [tie bars] in longitudinal and transverse contraction joints within the paving lane shall be held securely in place by means of rigid metal basket assemblies. The [dowels] [and tie bars] shall be welded to the assembly or held firmly by mechanical locking arrangements that will prevent them from becoming distorted during paving operations. The basket assemblies shall be held securely in the proper location by means of suitable anchors.

3.4.7.2 Construction Joints-Fixed Form Paving

Installation of [dowels] [and tie bars] shall be by the bonded-in-place method, supported by means of devices fastened to the forms. Installation by removing and replacing in preformed holes will not be permitted.

3.4.7.3 Dowels Installed in Hardened Concrete

Installation shall be by bonding the dowels into holes drilled into the hardened concrete. Holes approximately 3 mm 1/8 inch greater in diameter than the dowels shall be drilled into the hardened concrete. Dowels shall be bonded in the drilled holes using epoxy resin injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel shall not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic collar fitted around the dowel. The vertical alignment of the dowels shall be checked by placing the straightedge on the surface of the pavement over the top of the dowel and measuring the vertical distance between the straightedge and the beginning and ending point of the exposed part of the dowel. [Where tie bars are required in longitudinal construction joints of slipform pavement, bent tie bars shall be installed at the paver, in front of the transverse screed or extrusion plate. If tie bars are required, a standard keyway shall be constructed, and the bent tie bars shall be inserted into the plastic concrete through a 0.45 to 0.55 mm 26 gauge thick metal keyway liner. Tie bars shall not be installed in preformed holes. The keyway liner shall be protected and shall remain in place and become part of the joint. Before placement of the adjoining paving lane, the tie bars shall be straightened, without spalling the concrete around the bar.]

3.4.7.4 Expansion Joints

NOTE: Delete this paragraph if not required.

Dowels in expansion joints shall be installed by the bonded-in-place method or by bonding into holes drilled in hardened concrete, using procedures specified above.

3.5 FINISHING CONCRETE

Start finishing operations immediately after placement of concrete. Use finishing machine, except hand finishing may be used in emergencies and for concrete slabs in inaccessible locations or of such shapes or sizes that machine finishing is impracticable. Finish pavement surface on both sides of a joint to the same grade. Finish formed joints from a securely supported transverse bridge. Provide hand finishing equipment for use at all times. Transverse and longitudinal surface tolerances shall be 6 mm in 3 m 1/4 inch in 10 feet.

3.5.1 Side Form Finishing

Strike off and screed concrete to the required [crown] [slope] and cross-section by a power-driven transverse finishing machine. Transverse rotating tube or pipe shall not be permitted unless approved by the Contracting Officer. Elevation of concrete shall be such that, when consolidated and finished, pavement surface will be adequately consolidated and at the required grade. Equip finishing machine with two screeds which are readily and accurately adjustable for changes in pavement [crown] [slope] and compensation for wear and other causes. Make as many passes over each area of pavement and at such intervals as necessary to give proper compaction, retention of coarse aggregate near the finished surface, and a surface of uniform texture, true to grade and [crown] [slope]. Do not permit excessive operation over an area, which will result in an excess of mortar and water being brought to the surface.

3.5.1.1 Equipment Operation

Maintain the travel of machine on the forms without lifting, wobbling, or other variation of the machine which tend to affect the precision of concrete finish. Keep the tops of the forms clean by a device attached to the machine. During the first pass of the finishing machine, maintain a uniform ridge of concrete ahead of the front screed for its entire length.

3.5.1.2 Joint Finish

Before concrete is hardened, correct edge slump of pavement, exclusive of edge rounding, in excess of 6 mm 0.02 foot. Finish concrete surface on each side of construction joints to the same plane, and correct deviations before newly placed concrete has hardened.

3.5.1.3 Hand Finishing

Strike-off and screed surface of concrete to elevations slightly above finish grade so that when concrete is consolidated and finished pavement surface is at the indicated elevation. Vibrate entire surface until required compaction and reduction of surface voids is secured with a strike-off template.

3.5.1.4 Longitudinal Floating

After initial finishing, further smooth and consolidate concrete by means of hand-operated longitudinal floats. Use floats that are not less than 3.65 m 12 feet long and 150 mm 6 inches wide and stiffened to prevent flexing and warping.

3.5.2 Texturing

NOTE: Designer must select type of texturing required by the using service, retain that subparagraph, and delete the others. If no guidance is given, the usual default method should be burlap drag. Edit bracketed sentence as appropriate.

NOTE: Select the type of texturing for roads. Climatic conditions must be considered for exposed concrete. When required, specify surfaces to receive brooming.

1. Specify wire brooming for non-skid concrete surface textures. Permit steel or new fiber brooms.

2. Specify broomed finish, if required in lieu of burlap drag finish. Broomed finish may cause excessive tire wear and is not recommended, except for special conditions in which light mechanical brooming may be desirable.

3. Additional information is published by American Concrete Paving Association (ACPA) in Technical Bulletins No. 6 (1969) and No. 19 (1975), Interim Recommendations for the Construction of Skid-Resistant Concrete Pavement and Guideline for Texturing of Portland Cement Concrete Highway Pavements, respectively.

Before the surface sheen has disappeared and before the concrete hardens, the surface of the pavement shall be given a texture as described herein. Following initial texturing on the first day of placement, the Placing Foreman, Contracting Officer representative, and a representative of the Using Agency shall inspect the texturing for compliance with design requirements. After curing is complete, all textured surfaces shall be thoroughly power broomed to remove all debris. [Any type of transverse texturing shall produce grooves in straight lines across each lane within a tolerance of plus or minus 13 mm 1/2 inch of a true line.] The concrete in areas of recesses for tie-down anchors, lighting fixtures, and other outlets in the pavement shall be finished to provide a surface of the same texture as the surrounding area.

[3.5.2.1 Burlap Drag Finish

NOTE: Choose this paragraph or the paragraph above, or the paragraph below.

Before concrete becomes non-plastic, finish the surface of the slab by dragging on the surface a strip of clean, wet burlap measuring from 0.91 to 3 m 3 to 10 feet long and 600 mm 2 feet wider than the width of the pavement. Select dimension of burlap drag so that at least 0.91 m 3 feet of the material is in contact with the pavement. Drag the surface so as to

produce a finished surface with a fine granular or sandy texture without leaving disfiguring marks.

] [3.5.2.2 Brooming

NOTE: Choose this paragraph or one of the two paragraphs above.

Finish the surface of the slab by brooming the surface with a new wire broom at least 450 mm 18 inches wide. Gently pull the broom over the surface of the pavement from edge to edge just before the concrete becomes non-plastic. Slightly overlap adjacent strokes of the broom. Broom perpendicular to centerline of pavement so that corrugations produced will be uniform in character and width, and not more than 2 mm 1/16 inch in depth. Broomed surface shall be free from porous spots, irregularities, depressions, and small pockets or rough spots such as may be caused by accidentally disturbing particles of coarse aggregate embedded near the surface.

] [3.5.2.3 Wire-Comb Texturing

Surface texture transverse to the pavement center line shall be applied using a mechanical wire comb drag. The comb shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Successive passes of the comb shall be overlapped the minimum necessary to obtain a continuous and uniformly textured surface. The scores shall be 2 to 5 mm 1/16 to 3/16 inch deep, 1.5 to 3 mm 1/16 to 1/8 inch wide, and spaced 10 mm 3/8 inch apart.

] [3.5.2.4 Surface Grooving

The areas indicated on the drawings shall be grooved with a spring tine drag producing individual grooves 6 mm 1/4 inch deep and 6 mm 1/4 inch wide at a spacing between groove centerlines of 50 mm. 2 inches. These grooves shall be cut perpendicular to the centerline. Before grooving begins, the concrete shall be allowed to stiffen sufficiently to prevent dislodging of aggregate. Grooves shall not be cut within 150 mm 6 inches of a transverse joint or crack.

] 3.5.3 Edging

At the time the concrete has attained a degree of hardness suitable for edging, carefully finish slab edges, including edges at formed joints, with an edge having a maximum radius of 3 mm one-eighth inch. [When brooming is specified for the final surface finish, edge transverse joints before starting brooming, then operate broom to obliterate as much as possible the mark left by the edging tool without disturbing the rounded corner left by the edger.] Clean by removing loose fragments and soupy mortar from corners or edges of slabs which have crumbled and areas which lack sufficient mortar for proper finishing. Refill voids solidly with a mixture of suitable proportions and consistency and refinish. Remove unnecessary tool marks and edges. Remaining edges shall be smooth and true to line.

3.5.4 Repair of Surface Defects

Follow guidance of ACI 301.

3.6 CURING AND PROTECTION

Protect concrete adequately from injurious action by sun, rain, flowing water, [frost,] mechanical injury, tire marks and oil stains, and do not allow it to dry out from the time it is placed until the expiration of the minimum curing periods specified herein. Use White-Burlap-Polyethylene Sheet or liquid membrane-forming compound, except as specified otherwise herein. Do not use membrane-forming compound on surfaces where its appearance would be objectionable, on surfaces to be painted, where coverings are to be bonded to concrete, or on concrete to which other concrete is to be bonded. Maintain temperature of air next to concrete above 5 degrees C 40 degrees F for the full curing periods.

3.6.1 White-Burlap-Polyethylene Sheet

Wet entire exposed surface thoroughly with a fine spray of water, saturate burlap but do not have excessive water dripping off the burlap and then cover concrete with White-Burlap-Polyethylene Sheet, burlap side down. Lay sheets directly on concrete surface and overlap 300 mm 12 inches. Make sheeting not less than 450 mm 18 inches wider than concrete surface to be cured, and weight down on the edges and over the transverse laps to form closed joints. Repair or replace sheets when damaged during curing. Check daily to assure burlap has not lost all moisture. If moisture evaporates, resaturate burlap and re-place on pavement (re-saturation and re-placing shall take no longer than 10 minutes per sheet). Leave sheeting on concrete surface to be cured for at least 7 days.

3.6.2 Liquid Membrane-Forming Compound Curing

Apply compound immediately after surface loses its water sheen and has a dull appearance and before joints are sawed. Agitate curing compound thoroughly by mechanical means during use and apply uniformly in a two-coat continuous operation by suitable power-spraying equipment. Total coverage for the two coats shall be at least 4 liters one gallon of undiluted compound per 20 square meters 200 square feet. Compound shall form a uniform, continuous, coherent film that will not check, crack, or peel and shall be free from pinholes or other imperfections. Apply an additional coat of compound immediately to areas where film is defective. Respray concrete surfaces that are subject to heavy rainfall within 3 hours after curing compound has been applied in the same manner.

3.6.2.1 Protection of Treated Surfaces

Keep concrete surfaces to which liquid membrane-forming compounds have been applied free from vehicular traffic and other sources of abrasion for not less than 72 hours. Foot traffic is allowed after 24 hours for inspection purposes. Maintain continuity of coating for entire curing period and repair damage to coating immediately.

[3.6.3 Liquid Chemical Sealer-Hardener

Apply sealer-hardener to interior floors not receiving floor covering and floors located under access flooring. Apply the sealer-hardener in accordance with manufacturer's recommendations. Seal or cover joints and openings in which joint sealant is to be applied as required by the joint sealant manufacturer. The sealer-hardener shall not be applied until the concrete has been moist cured and has aged for a minimum of 30 days. Apply a minimum of two coats of sealer-hardener.

] 3.7 FIELD QUALITY CONTROL

3.7.1 Sampling

The Contractor's approved laboratory shall collect samples of fresh concrete in accordance with ASTM C 172 during each working day as required to perform tests specified herein. Make test specimens in accordance with ASTM C 31/C 31M.

3.7.2 Consistency Tests

The Contractor's approved laboratory shall perform concrete slump tests in accordance with ASTM C 143/C 143M. Take samples for slump determination from concrete during placement. Perform tests at the beginning of a concrete placement operation and for each batch (minimum) or every 16 cubic meters 20 cubic yards (maximum) of concrete to ensure that specification requirements are met. In addition, perform tests each time test beams and cylinders are made.

3.7.3 Flexural Strength Tests

NOTE: This specification is based on a flexural strength basis. For small jobs compressive strength may be used. In that case modify these paragraphs to reflect a compressive strength basis.

The Contractor's approved laboratory shall test for flexural strength in accordance with ASTM C 78. Make four test specimens for each set of tests. Test two specimens at [7] [28] days, and the other two at [28] [90] days. Concrete strength will be considered satisfactory when the minimum of the [28] [90]-day test results equals or exceeds the specified [28] [90]-day flexural strength, and no individual strength test is less than [3.79] [] MPa [550] [] pounds per square inch. If the ratio of the [7] [28]-day strength test to the specified [28] [90]-day strength is less than 65 percent, make necessary adjustments for conformance. Frequency of flexural tests on concrete beams shall be not less than four test beams for each 38 cubic meters 50 cubic yards of concrete, or fraction thereof, placed. Concrete which is determined to be defective, based on the strength acceptance criteria therein, shall be removed and replaced with acceptable concrete.

3.7.4 Air Content Tests

Test air-entrained concrete for air content at the same frequency as specified for slump tests. Determine percentage of air in accordance with ASTM C 231 on samples taken during placement of concrete in forms.

3.7.5 Surface Testing

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.

Surface testing for surface smoothness [, edge slump] and plan grade shall be performed as indicated below by the Testing Laboratory. The measurements shall be properly referenced in accordance with paving lane identification and stationing, and a report given to the Government within 24 hours after measurement is made. 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, shall be provided to the Government upon conclusion of surface testing.

3.7.5.1 Surface Smoothness Requirements

The finished surfaces of the pavements shall have no abrupt change of 3 mm 1/8 inch or more, and all pavements shall be within the tolerances specified when checked with a 4 meter 12 foot straightedge: 5 mm 1/5 inch longitudinal and 6.5 mm 1/4 inch transverse directions for roads and streets and 6.5 mm 1/4 inch for both directions for other concrete surfaces, such as parking areas.

3.7.5.2 Surface Smoothness Testing Method

The surface of the pavement shall be tested with the straightedge to identify all surface irregularities exceeding the tolerances specified above. The entire area of the pavement shall be tested in both a longitudinal and a transverse direction on parallel lines approximately 4.5 m 15 feet apart. The straightedge shall be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined 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.

3.7.6 Plan Grade Testing and Conformance

The surfaces shall vary not more than 18 mm 0.06 foot above or below the plan grade line or elevation indicated. Each pavement category shall be checked by the Contractor for conformance with plan grade requirements by running lines of levels at intervals to determine the elevation at each joint intersection.

3.7.7 Test for Pavement Thickness

Measure during concrete placement to determine in-place thickness of concrete pavement.

3.7.8 Reinforcement

Inspect reinforcement prior to installation to assure it is free of loose flaky rust, loose scale, oil, mud, or other objectionable material.

3.7.9 Dowels

Inspect dowel placement prior to placing concrete to assure that dowels are of the size indicated, and are spaced, aligned and painted and oiled as specified. Dowels shall not deviate from vertical or horizontal alignment after concrete has been placed by more than 3 mm per 300 mm 1/8 inch per foot.

NOTE: Suggestions for improvement of this
specification will be welcomed using the Navy
"Change Request Forms" subdirectory located in
SPECSINTACT in Jobs or Masters under
"Forms/Documents" directory or DD Form 1426.
Suggestions should be forwarded to:

Commander
Naval Facilities Engineering Command
Engineering Innovation and Criteria Office, Code EICO
1510 Gilbert Street
Norfolk, VA 23511-2699

FAX: (757) 322-4416 or
Email: cgs@efdlant.navfac.navy.mil

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