
USACE / NAVFAC / AFCEC / NASA UFGS-32 13 43 (October 2011)
Change 1 - 11/13

Preparing Activity: NAVFAC NEW

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2017

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SECTION 32 13 43

PERVIOUS CONCRETE PAVING
11/11

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

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

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

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

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.

Porous PCCP should not be used in areas with extensive winter maintenance and in areas where high wind is common (material can be wind blown and clog the pavement pores). Additionally, this pavement should not be used where there is heavy truck traffic.

PART 1 GENERAL

1.1 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 Reference Identifier (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 CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 305R	(2010) Guide to Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting
ACI 522.1	(2013) Specification For Pervious Concrete Pavement

ASTM INTERNATIONAL (ASTM)

ASTM C1077	(2016) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C1157/C1157M	(2011) Standard Specification for Hydraulic Cement
ASTM C1260	(2014) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C140/C140M	(2016) Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
ASTM C150/C150M	(2016; E 2016) Standard Specification for Portland Cement

ASTM C1567	(2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2012) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C1688/C1688M	(2014a) Standard Test Method For Density And Void Content Of Freshly Mixed Pervious Concrete
ASTM C171	(2016) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2014a) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C174/C174M	(2016) Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C33/C33M	(2016) Standard Specification for Concrete Aggregates
ASTM C42/C42M	(2013) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C494/C494M	(2016) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2016) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C94/C94M	(2016a) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2014) Standard Specification for Slag Cement for Use in Concrete and Mortars

1.2 RELATED SECTIONS

NOTE: Pervious pavement systems shall not be installed in areas subject to high wheel loads (aircraft, ground support equipment, forklifts, etc.). Consult manufacturer's recommendations for cold regions, arid regions, and regions with high wind erosion. Pervious concrete

in freezing areas should be designed with adequate base thickness to ensure that water does not remain in the pavement layer during freezing conditions. Parking lots are generally good pervious pavement applications. Installing pervious pavement systems contributes to the following LEED credits: SS6, SS7, WE1, MR4, and MR5.

Pervious pavement systems shall use Section 32 11 16.16 [BASE COURSE FOR RIGID] [AND SUBBASE COURSE FOR FLEXIBLE] [SUBBASE COURSE FOR PERVIOUS] PAVING 32 11 24 GRADED CRUSHED AGGREGATE BASE COURSE FOR [PERVIOUS] [FLEXIBLE] PAVEMENT, in addition to this section.

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.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

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

Use the "S" classification only in SD-11 Closeout Submittals. The "S" following a submittal item indicates that the submittal is required for the Sustainability eNotebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

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.] Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data; G[, [_____]]

Curing materials

Admixtures

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

Aggregates

Cementitious Materials; (LEED)

[Local/Regional Materials; (LEED)

Submit documentation indicating distance between manufacturing facility and the project site. Indicate distance of raw material origin from the project site. Indicate relative dollar value of local/regional materials to total dollar value of products included in project.

][Albedo; (LEED)

Provide information identifying the reflectance of the pavement.

] SD-04 Samples

[Field-Constructed Mockup

] SD-05 Design Data ; G[, [_____]]

Concrete mix design

Thirty days minimum prior to concrete placement, submit a mix design with applicable tests for approval. Submit a complete list of materials including type; brand; source and amount of cement, fly ash, slag, coarse aggregate, fine aggregate, and admixtures; and applicable reference specifications. Provide mix proportion data using a recognized proportioning procedure. Provide separate mixture proportions and test data for each coarse aggregate source and size proposed for use. 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 aggregate or raw material supplier change.

SD-06 Test Reports

Aggregate tests

Cementitious Materials

Concrete density tests

SD-07 Certificates; G[, [____]]

Ready-mixed concrete plant

Ready-mixed concrete truck

Batch tickets

Cementitious materials

SD-11 Closeout Submittals

[Local/Regional Materials; (LEED); G[, [____]]

LEED documentation relative to local/regional materials credit in accordance with LEED Reference Guide. Include in LEED Documentation Notebook.

] Cementitious Materials; (LEED)

Albedo; (LEED)

LEED documentation relative to heat island effect - non-roof credit in accordance with LEED Reference Guide. Include in LEED Documentation Notebook.

1.4 DELIVERY AND STORAGE

ASTM C94/C94M.

1.5 QUALITY ASSURANCE

1.5.1 Ready-mixed Concrete Plant and Ready-mixed Concrete Truck

Unless otherwise approved by the Contracting Officer, ready mixed pervious concrete shall be produced and provided by a National Ready-Mix Concrete Association (NRMCA) certified plant. If a volumetric mobile mixer is used to produce the pervious concrete, rather than ready-mixed pervious concrete, the mixer(s) must conform to the standards of the Volumetric Mixer Manufacturers Bureau (VMMB). Verification shall be made by a current VMMB conformance plate affixed to the volumetric mixer equipment.

1.5.2 Contractor Qualifications

Unless waived by the Contracting Officer, the Contractor shall meet one of the following criteria:

- a. Contractor shall have at least one National Ready Mixed Concrete Association (NMRCA) certified pervious concrete craftsman on site, overseeing each placement crew during all concrete placement.
- b. Contractor shall have no less than three NRMCA certified pervious concrete installers, who shall be on site working as members of each placement crew during all concrete placement.

1.5.3 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, combined aggregate gradation analysis, percentage retained and passing sieve, and a graph of percentage retained versus 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 C1077. The laboratory shall be approved in writing by the Government.

1.5.4 Batch Tickets

ASTM C94/C94M. Submit mandatory batch ticket information for each load of ready-mixed concrete.

1.5.5 Field-Constructed Mock Up

NOTE: Pervious pavement (permeable pavement) is a permeable surface with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. This permeable surface replaces traditional pavement, allowing parking lot storm water to infiltrate directly and receive water quality treatment. Pervious asphalt and concrete may appear to be similar to traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration.

Install a minimum 37 square meters 400 square feet to demonstrate typical joints, surface finish, texture, color, permeability, thickness, density, and standard of workmanship. Test panels shall be placed using the mixture proportions, materials, and equipment as proposed for the project. Test mock up panels in accordance with requirements in subpart 3.7, FIELD QUALITY CONTROL.

When a test panel is does not meet one or more of the requirements, the test panel shall be rejected, removed, and replaced at the Contractor's expense. If the test panels are acceptable, they may be incorporated into the project with the approval of the Contracting Officer.

1.6 SUSTAINABLE DESIGN REQUIREMENTS

1.6.1 Local/Regional Materials

NOTE: Using local materials can help minimize transportation impacts, including fossil fuel consumption, air pollution, and labor. Using materials harvested and manufactured within a 500 mile radius from the project site contributes to the following LEED credit: MR5. Coordinate with Section

01 33 29 LEED(tm) DOCUMENTATION. Use second option if Contractor is choosing local materials in accordance with Section 01 33 29 LEED(tm) DOCUMENTATION. First option shall not be used for USACE projects. Army projects shall include second option only if pursuing this LEED credit.

[Use materials or products extracted, harvested, or recovered, as well as manufactured, within a [800][_____] kilometer [500][_____] mile radius from the project site, if available from a minimum of three sources.][See Section 01 33 29 LEED(tm) DOCUMENTATION for cumulative total local material requirements. Pavement materials may be locally available.

]PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

NOTE: ASTM C595 covers three kinds of blended hydraulic cements. The three types are as follows:

1. Portland Blast - Furnace Slag Cement (Type IS).
2. Portland - Pozzolan Cement (Types IP and P).
3. Ternary blended Cement (Type IT).

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.

NOTE: Cement is 10 to 15 percent of concrete, but is more energy intensive than the other constituents. Use the minimum amount of cement required for a project to produce quality concrete. Fly ash is not commonly used as a replacement for portland cement at the 40 percent level and needs to be tested extensively for compatibility and performance if used in this manner. Include the last sentence of the following paragraph if fly ash replaces 40 percent of portland cement. Concrete and cement are EPA designated products for recycled content. See Section 01 33 29 SUSTAINABILITY REPORTING and include minimum recycled content options unless designer determines that justification for non-use exists. Designer must verify suitability, availability and adequate competition (including verification of bracketed percentages included in this guide specification)

before specifying products meeting EPA minimum recycled content.

Use of materials with recycled content, calculated on the basis of post-industrial and post-consumer percentage content, contributes to the following LEED credit: MR4. Coordinate with Section 01 33 29 LEED(tm) DOCUMENTATION. Designer must verify suitability, availability and adequate competition (including verification of bracketed percentages included in this guide specification) before specifying product recycled content requirements. Use second option if Contractor is choosing recycled content products in accordance with Section 01 33 29 LEED(tm) DOCUMENTATION. Army projects shall specify recycled content exceeding EPA requirements only if pursuing this LEED credit.

Cementitious materials in concrete mix shall be 20 to 50 percent non-portland cement pozzolanic materials by weight. [Provide test data demonstrating compatibility and performance of concrete satisfactory to Contracting Officer.]

2.1.1.1 Cement

ASTM C150/C150M, Type I or II [III, for high early concrete] [or V] [low alkali] or ASTM C595/C595M, Type IS, IP, or P [MS] [MH] [mortar expansion] or ASTM C1157/C1157M [MS] [HS] [R].

NOTE: A maximum alkali content of 0.40 percent is more desirable and should be used where available. However, the availability of low alkali cement is extremely limited and is not economically feasible in most cases. Therefore the use of low alkali cement 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 C618, should provide acceptable end results.

ASTM C618, Type C, F, or N. Fly ash certificates shall include test results in accordance with ASTM C618.

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

2.1.1.3 Slag

ASTM C989/C989M, Slag Cement (formerly Ground Granulated Blast Furnace Slag) Grade 100 or 120. Certificates shall include test results in accordance with ASTM C989/C989M.

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

2.1.2 Water

Water shall conform to ASTM C1602/C1602M. Hot water shall not be used unless approved by the Contracting Officer.

2.1.3 Aggregate Tests

Use of materials with recycled content, calculated on the basis of post-industrial and post-consumer percentage content, contributes to the following LEED credit: MR4. Coordinate with Section 01 33 29 LEED(tm) DOCUMENTATION. Designer must verify suitability, availability and adequate competition (including verification of bracketed percentages included in this guide specification) before specifying product recycled content requirements. Use second option if Contractor is choosing recycled content products in accordance with Section 01 33 29 LEED(tm) DOCUMENTATION. Army projects shall specify recycled content only if pursuing this LEED credit.

Coarse aggregate shall consist of crushed or uncrushed gravel, crushed stone, or a combination thereof. Aggregates, as delivered to the mixers, shall consist of clean, hard, uncoated particles. Coarse aggregate shall be washed. Washing shall be sufficient to remove dust and other coatings. Fine aggregate shall consist of natural sand, manufactured sand, or a combination of the two, and shall be composed of clean, hard, durable particles. Both coarse and fine aggregates shall meet the requirements of ASTM C33/C33M.

2.1.3.1 Alkali Reactivity Test

NOTE: While not wholly conclusive, petrographic examination (ASTM C295/C295M) and the Chemical Test Method (ASTM C28/C28M) 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 C1293) is also a valuable indicator. ASTM C1293 is ineffective in hot and humid climates. However, none of the methods above constitutes a substitute for the modified ASTM C1260.

NOTE: The most important rocks and mineral known to be deleteriously reactive with the alkalis in Portland cement are listed in ASTM C33 (and ASTM C294). 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.

Aggregates to be used in all concrete in projects over 9290 SM 100,000 SFin size shall be evaluated and tested by the Contractor for alkali-aggregate reactivity in accordance with ASTM C1260. The types of aggregates shall be evaluated in a combination which matches the contractors' proposed mix design (including Class F fly ash or GGBF slag), utilizing ASTM C1567. Test results of the combination shall have a measured expansion of less than 0.08 percent at 28 days. Should the test data indicate an expansion of greater than 0.08 percent, 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 C1260 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 various types of aggregates also be evaluated separately, in accordance with the original ASTM C1260, to ascertain the specific reactivity of each aggregate.

2.1.3.2 Fine Aggregates

ASTM C33/C33M.

2.1.3.3 Coarse Aggregates

NOTE: For pervious concrete, use No.67 (3/4 inch to No.4), No.8 (3/8 inch to No.16) or No.89 (3/8 inch to No. 50) so as to provide 15 percent to 20 percent percent optimum void factor in hardened concrete.

- a. Gradation: ASTM C33/C33M, [#67][#8][#89].
- b. Quality: ASTM C33/C33M, Class 4M or 4S, depending on weathering region.
- c. Alkali-Silica Reactivity: Test in accordance with ASTM C1260, as specified in ASTM C33/C33M, Appendix XI. Aggregates failing to meet the expansion limit of 0.08 percent at 16 days after casting shall be replaced or mitigated using fly ash, pozzolan, or slag in accordance with ASTM C1567.

2.1.4 Admixtures

ASTM C494/C494M: Type A, water reducing; Type B, retarding; and Type D, water-reducing and retarding, except acceptance shall be based on 28 day physical properties. 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 C260/C260M: Air-entraining.

2.1.5 Curing Materials

2.1.5.1 Polyethylene Sheet

ASTM C171, 0.15 mm 0.006 inch clear or white opaque polyethylene cut to a minimum of 600mm 24 inches wider than full placement width, for curing of pervious concrete.

[2.1.6 Edge Restraints

Edge restraints for pervious systems shall be [concrete][_____].

]2.2 CONCRETE PAVEMENT

2.2.1 Albedo

NOTE: The urban heat island effect forms as vegetation is replaced by low reflectivity materials such as dark colored paving. These surfaces absorb - rather than reflect - the sun's heat, causing surface temperatures and urban ambient temperatures to be 1 to 6 degrees C 2 to 10 degrees F hotter than surrounding rural areas. Using high-albedo materials contributes to the following LEED credit: SS7. Coordinate with Section 01 33 29 LEED(tm) DOCUMENTATION. Army projects shall specify

bracketed LEED option only if pursuing this LEED credit.

[Installed system must meet the requirements of LEED heat island effect non-roof credit SS 7.1, having a Solar Reflectance Index (SRI) of at least 29.

]2.3 CONTRACTOR-FURNISHED MIX DESIGN

NOTE: Flexural strength tests do not apply to pervious concrete. Pervious concrete is air-entrained per manufacturer's recommendations for freeze thaw durability. However, due to the open void structure of the material, air content cannot be measured by standard ASTM test procedures.

NOTE: Coordinate with Contracting Officer for mix design requirement to satisfy project albedo and permeability needs.

Contractor-furnished mix design concrete shall be designed in accordance with ACI 522.1 except as modified herein, and the mix design shall be as specified herein under paragraph entitled "Submittals." The concrete may be air entrained. The minimum cement factor shall be 227 kg 500 lbs.

The water/cementitious materials ratio shall be 0.26-0.40. The air voids shall be 18 to 22 percent, as measured in accordance with ASTM C1688/C1688M.

PART 3 EXECUTION

NOTE: Dowel bars and reinforcement are not used in pervious concrete applications.

3.1 PREPARATION FOR PERVIOUS SYSTEMS

Verify compacted subgrade, granular base or stabilized soil is acceptable and ready to support paving and imposed loads. Subgrade compaction shall not exceed 94 percent of modified proctor. Install edge restraints per the drawings and manufacturer's recommendations.

3.2 FORMS

3.2.1 Construction

Construct forms to be removable without damaging the concrete.

3.2.2 Coating

Before placing the concrete, coat the contact surfaces of forms 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, but do not apply form release agent to previously placed concrete.]

3.2.3 Grade and Alignment

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

3.3 MEASURING, MIXING, CONVEYING, AND PLACING CONCRETE

3.3.1 Measuring

ASTM C94/C94M.

3.3.2 Mixing

ASTM C94/C94M, except as modified herein. Begin mixing immediately after cement has been added to aggregates. When the air temperature is greater than 29.4 degrees C 85 degrees F, place concrete within 60 minutes. With the approval of the Contracting Officer, a hydration stabilizer admixture meeting the requirements of ASTM C494/C494M Type D, may be used to extend the placement time to 90 minutes. Additional water may be added to enhance workability up to a level acceptable to the contractor without causing paste drain or exceeding the specified water-cement ratio.

3.3.3 Conveying

ASTM C94/C94M, pervious concrete may not be placed by pumping.

3.3.4 Placing

Placement of pervious concrete should comply with guidelines set in ACI 522.1, except as modified herein. Do not exceed a free vertical drop of 1.5 m 5 feet. 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. Deposit concrete either directly from the transporting equipment or by conveyor on to the pre-wetted subgrade or subbase, unless otherwise specified. Do not place concrete on frozen subgrade or subbase. Deposit the concrete between the forms to an approximately uniform height. Spread the concrete using a come-along, square ended shovel, or rake. Do not allow foot traffic on the fresh concrete. Strike off the concrete between forms using a form-riding paving machine or vibrating screed. Other strike off devices may be used with the approval of the contracting officer. Place concrete continuously at a uniform rate, with a 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 m 10 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. Do not use steel trowels or power finishing equipment. Finish the pavement to the elevations and thickness specified or indicated and compact the fresh concrete to meet the requirements of final finish as described herein. Compact the concrete along the slab edges with hand tools. Compact concrete to a dense, pervious surface. Edge top surface to a radius of not less than 6 mm 1/4 inch, where required. Construct the pavement to comply with the following tolerances:

- a. Elevation: plus 19 mm; minus 0 mm plus 3/4 inch; minus 0 inch
- b. Thickness: plus 37 mm; minus 6 mm plus 1.5 inches; minus 1/4 inch
- c. Contraction joint depth: plus 6 mm; minus 0mm plus 1/4 inch; minus 0 inch

Mechanically sweep pavement before testing hardened concrete for compliance tolerances.

3.3.5 Cold Weather

NOTE: Accelerators should not be used with pervious concrete.

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 without approval from the contracting officer. If approval is granted, heat concrete materials so that the temperature of the concrete at placement is between 18 and 29 degrees C 65 and 80 degrees F. Methods of heating materials are subject to approval by the Contracting Officer. Do not use heated mixing water. Follow practices found in ACI 306.1.

3.3.6 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 within 20 minutes of concrete discharge. Cool underlying material by sprinkling lightly with water before placing concrete.

3.4 PAVING

[Install pervious paving system in accordance with manufacturer's recommendations and as indicated. Install surface elevation of the paving system 3 to 6 mm 1/8 to 1/4 inch above adjacent drainage inlets, concrete collars, or channels. Manufacturer's recommendations shall take precedence over the specifications in the event of conflicting requirements between the two.]Pavement shall be constructed with paving and finishing equipment utilizing [fixed forms].

3.4.1 Consolidation

Surface vibration shall be automatically controlled so that it 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 tamped. Vibrators shall not be used to transport or spread the concrete.

3.4.2 Operation

When paving 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.

3.4.3 Required Results

The paving equipment 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, and any other discontinuities. The equipment and its operation shall produce a finished surface requiring no hand finishing, other than the use of jointing tools, 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

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. [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 Slip Form Paving

When approved for use by the Contracting Officer, 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.

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. When using a static roller for consolidation, the roller must be stiffened to prevent flexing and warping straightness tolerance must be 6 mm .25 in in 3 m 10 ft. 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 consolidation, further smooth and consolidate concrete by means of hand-operated longitudinal rollers. Use rollers that are not less than 1.82 m 6 feet long and 200 mm 8 inches in diameter and stiffened to prevent flexing and warping.

3.5.2 Edging

Immediately after consolidation and jointing, carefully finish slab edges, including edges at formed joints, with an edge having a radius of not less than 6 mm 0.25 inch. 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. [Install edge restraints of pervious systems per the drawings and manufacturer's recommendations.]

NOTE: Drawings should clearly show all pavement joints. If the jointing plan on the project drawings is not compatible with the contractor's placement sequence, the contractor may submit a plan shop drawing indicating joint locations.

3.5.3 Jointing

Construct joints at the locations, depths, and width dimensions indicated on the project drawings or the approved shop drawings submitted by the contractor. Tool contraction joints in fresh concrete immediately after the concrete has been compacted to the specified depth and width. Do not sawcut joints. Extend expansion joints through the full depth of the pavement. Cut expansion material flush to grade after concrete has fully hardened and provide joint filler material as indicated or as approved on the shop drawings submitted by the Contractor.

3.5.3.1 Joint Layout Drawings

If jointing requirements on the project drawings are not compatible with the contractor's placement sequence, the contractor shall submit a joint layout plan shop drawing to the Contracting Officer for approval. No work shall be allowed to start until the joint layout plan is approved. The joint layout plan shall indicate and describe in the detail the proposed jointing plan for contraction joints, expansion joints, and construction joints, in accordance with the following:

- a. Indicate locations of contraction joints, construction joints, and expansion joints. Spacing between contraction joints shall not exceed 4.5m 15 feet unless noted otherwise or approved by the Contracting Officer.
- b. The larger dimension of a panel shall not be greater than 125 percent of the smaller dimension.
- c. The minimum angle between two intersecting joints shall be 80 degrees, unless noted otherwise or approved by the Contracting Officer.
- d. Joints shall intersect pavement-free edges at a 90 degree angle the pavement edge and shall extend straight for a minimum of 450mm 1.5 feet from the pavement edge, where possible.
- e. Align joints of adjacent panels.
- f. Align joints in attached curbs with joints in pavement when possible.
- g. Ensure joint depth, widths, and dimensions are specified.
- h. Minimum contraction joint depth shall be 1/4 of the pavement thickness. The minimum joint width shall be 3mm 1/8 inch.
- i. Use expansion joints only where pavement abuts buildings, foundations, manholes, and other fixed objects.

3.6 CURING AND PROTECTION

Curing of pervious concrete shall be in accordance with ACI 522.1. 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-Polyethylene Sheet, except as specified otherwise herein. Do not use membrane-forming compound. Maintain temperature of air next to concrete above 5 degrees C 40 degrees F for the full curing periods.

3.6.1 White-Polyethylene Sheet

Begin curing within 20 minutes of concrete discharge unless longer working time is accepted by the Contracting Officer. Lay sheets directly on concrete surface and overlap 300 mm 12 inches. Make sheeting not less than 600 mm 24 inches wider than concrete surface to be cured, and weight down on the edges, without using soil or debris, and over the transverse laps to form closed joints. Repair or replace sheets when damaged during curing. Check daily to assure sheets are soundly in place. If moisture evaporates, re-saturate concrete and replace polyethylene 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.

3.7 FIELD QUALITY CONTROL

3.7.1 Sampling

The Contractor's approved laboratory shall collect samples of fresh concrete in accordance with ASTM C172/C172M during each working day as required to perform tests specified herein.

3.7.2 Consistency Tests

The Contractor's approved laboratory shall perform concrete density tests on the fresh concrete in accordance with ASTM C1688/C1688M. Take samples for density determination from concrete during placement. Perform tests at the beginning of a concrete placement operation and for each batch (minimum) or every 40 cubic meters 50 cubic yards (maximum) of concrete to ensure that specification requirements are met. The fresh density shall be within plus or minus 80 K/CM 5 lb/CF of the accepted fresh density from the submitted mixture proportions.

3.7.3 Sample Cores

After a minimum of 7 days following each placement, three cores shall be taken at random per the Contracting Officer's discretion. Core hardened concrete panels in accordance with ASTM C42/C42M Test thickness and density of the cores in accordance with ASTM C174/C174M and paragraph 9.3 of ASTM C140/C140M, respectively. Tolerance for thickness and density reported as the average of three cores of each test panel shall be as follows:

- a. The average compacted thickness shall not be more than 6mm .25 in less than the specified thickness.
- b. The average compacted thickness shall not exceed the specified thickness by more than 38mm 1.5 in.
- c. The average hardened density shall be within plus or minus 5 percent of the accepted hardened density of the test panels.

Core holes shall be filled with regular concrete or pre-mixed grout.

3.7.4 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.

3.7.4.1 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.][variations in final pervious surface shall not be more than [10][_____] mm [3/8][_____] inch under a 3.0 m 10 foot straightedge.]

3.7.4.2 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. Measurement of the gap shall be made with a steel spacer bar of rectangular section the same thickness as the allowable gap, and width of four times the nominal maximum aggregate size.

3.7.5 Plan Grade Testing and Conformance

The surfaces shall vary not more than 18 mm 0.06 foot above or 0.0 m 0.0 feet 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.

3.7.6 OPEN TO TRAFFIC

Do not open the pavement to vehicular traffic until the concrete has cured at least fourteen (14) days or until the pavement is accepted by the Contracting Officer.

3.8 WASTE MANAGEMENT

**NOTE: Diverting waste from the landfill contributes
to the following LEED credit: MR2. Coordinate with**

Section 01 33 29 LEED(tm) DOCUMENTATION. Designer shall verify that items are able to be disposed of as specified.

In accordance with the Waste Management Plan.[Protect excess material from contamination and return to manufacturer, or reuse on-site for walkways, patching, ditch beds, speed bumps, or curbs.]

-- End of Section --