

SPECIFICATION P-501. PORTLAND CEMENT CONCRETE PAVEMENT

DESCRIPTION

501-1.1 This Work consists of pavement composed of Portland cement concrete, constructed on a prepared underlying surface in accordance with these Specifications and shall conform to the lines, grades, thickness, and typical cross sections shown on the Plans. Reinforcement is required when shown on the Plans.

MATERIALS

501-2.1 AGGREGATES.

a. Reactivity. Aggregate shall be free of substances that are deleteriously reactive with the alkalis in the cement in an amount sufficient to cause excessive expansion of the concrete. Acceptable aggregate shall be based on satisfactory evidence furnished by the Contractor that the aggregate is free from these materials. Include as part of the evidence service records of concrete of comparable properties under similar conditions of exposure and/or certified records of tests by a testing laboratory that meets the requirements of ASTM C 1077. Test aggregate in accordance with ASTM C 295. If reactive materials are identified, test the aggregate in accordance with ASTM C 289. If the results are positive, test the aggregate in accordance with ASTM C 227.

NOTE TO SPECIFIER:

Aggregates from operational pits and quarries can be relied upon only if there is evidence that the nature of the aggregate has not changed as the quarry is exhausted.

The tests for reactivity in the Standard Specifications were based on the following recommendations. Normally the tests are performed in specific order. The petrographic analysis (ASTM C 295) is conducted first. If reactive minerals are identified, a quick chemical test (ASTM C 289) is conducted. If the results are positive, a mortar-bar expansion test (ASTM C 227) is conducted.

While not wholly conclusive, petrographic examination (ASTM C 295) and chemical test (ASTM C 289), provide valuable indicators. However, ASTM C 289 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 mortar bar method (ASTM C 227) while preferable and more reliable, requires at least 6 months and preferably one year to yield results. It should be used for new sources of aggregate.

See ASTM C 33, Appendix X1, Methods for Evaluating Potential Reactivity of An Aggregate for additional information.

Proposed test method ASTM P 214, Accelerated Detection of Potentially Deleterious Expansion of Mortar Bars Due to Alkali-Silica Reaction, may be substituted for ASTM C 227 at the option of the Engineer, including test parameters.

b. Fine Aggregate. Fine aggregate shall conform to the requirements of ASTM C 33. Gradation shall meet the requirements of Table 1 when tested in accordance with ASTM C 136, except as may otherwise be qualified under Section 5 of ASTM C 33. Fine aggregate shall comprise 30 to 45 percent of total aggregate (fine aggregate plus coarse aggregate).

**TABLE 1. GRADATION FOR FINE AGGREGATE
ASTM C 33**

<i>Sieve Designation (square openings)</i>		<i>Percentage by Weight Passing Sieves</i>
<i>in.</i>	<i>mm.</i>	
3/8 in.	9.5 mm	100
No. 4	4.75 mm	95–100
No. 8	2.36 mm	80–100
No. 16	1.18 mm	50–85
No. 30	600 micro–m	25–60
No. 50	300 micro–m	10–30
No. 100	150 micro–m	2–10

c. Coarse Aggregate. Coarse aggregate shall conform to the requirements of ASTM C 33. Gradation, within the separated size groups, shall meet the requirements of Table 2 when tested in accordance with ASTM C 136. When the nominal maximum size of the aggregate is greater than one inch, furnish the aggregates in two size groups.

Aggregates delivered to the mixer shall consist of crushed stone, crushed or uncrushed gravel, air-cooled blast furnace slag, crushed recycled concrete pavement, or a combination thereof. The aggregate shall be composed of clean, hard, uncoated particles and shall meet the requirements for deleterious substances contained in ASTM C 33, Class 4S. Remove dust and other coating from the aggregates by washing. The aggregate in different size groups shall not contain more than 8 percent by weight of flat or elongated pieces when tested in accordance with ASTM D 4791. A flat or elongated particle is one having a ratio between the maximum and the minimum dimensions of a circumscribing rectangular prism exceeding 5 to 1.

Prior to approval of mixture design, submit written certification that the aggregate does not have a history of D-Cracking and that the aggregate is approved by the Division of Transportation, Infrastructure Development specifically addressing susceptibility to D-Cracking. If the aggregate is not approved by the Division of Transportation, Infrastructure Development, the aggregates may be approved provided the aggregate is tested in accordance with ASTM C 666 and receives a durability factor of 95 percent or greater.

NOTE TO SPECIFIER:

Class was specified in accordance with Table 3 of ASTM C 33. ASTM C 666, Resistance of Concrete to Rapid Freezing and Thawing, was added to the list of testing requirements.

The percentage of wear shall be no more than 40 percent when tested in accordance with ASTM C 131 or ASTM C 535.

NOTE TO SPECIFIER:

The percentage of wear was specified per FAA to not exceed 40 percent. In certain cases where aggregate of this quality cannot be obtained economically, aggregate with a higher percentage of wear may be specified in a Special Provision if a satisfactory service record of at least 5 years' duration under similar conditions of service and exposure has been demonstrated.

The FAA recommended gradations were inserted into Table 2 of the Standard Specifications. Where locally available aggregates cannot be economically blended to meet the grading requirements, the gradations may be modified by the Engineer to fit the characteristics of locally available aggregates by Special Provision upon approval of WBOA and ADO.

The concrete mix design shall be based upon use of Coarse Aggregate (C.A.) Mix unless otherwise specified in the Plans or Special Provisions. In C.A. Mix A and B, aggregate sizes No. 3 and No. 4 shall comprise 35 to 65 percent of the total amount of coarse aggregate.

TABLE 2. GRADATION FOR COARSE AGGREGATE

Sieve Designations (square openings)		Percentage by Weight Passing Sieves				
		C.A. Mix A From 2" to No. 4 (50.0 mm–4.75 mm)		C.A. Mix B From 1–1/2" to No. 4 (38.0 mm–4.75 mm)		C.A. Mix C From 1" to No. 4 (25.0 mm–4.75 mm)
in.	mm	No. 3* (2" – 1")	No. 57* (1" – No. 4)	No. 4* (1–1/2"–3/4")	No. 67* (3/4"–No.4)	No. 57* (1"–No.4)
2–1/2	63	100	—	—	—	—
2	50.0	90–100	—	100	—	—
1–1/2	38.0	35–70	100	90–100	—	100
1	25.0	0–15	95–100	20–55	100	95–100
3/4	19.0	—	—	0–15	90–100	—
1/2	12.5	0–5	25–60	—	—	25–60
3/8	9.5	—	—	0–5	20–55	—
No. 4	4.75	—	0–10	—	0–10	0–10
No. 8	2.36	—	0–5	—	0–5	0–5

* ASTM C 33 Table 2 Size Number

501–2.2 CEMENT. Cement shall conform to the requirements of ASTM C 150 Type I, Type II, or Type III.

NOTE TO SPECIFIER:

The FAA allows the following: ASTM C 150 – Type I, II, III, or IV. ASTM C 595 – Type IP, IS, S, I. Type I, Type II, or Type III cement was used in the Standard Specifications other types may be specified in the Special Provisions.

ASTM C 150 covers Portland cements. ASTM C 595 covers blended hydraulic cements as follows: IP – Portland–Pozzolan Cement, IS – Portland Blast–Furnace Slag Cements, S – Slag Cement, I – Pozzolan Modified–Portland Cement.

The chemical requirements for all cement types specified should meet suitable criteria for deleterious activity in accordance with ASTM C 33 or based on historical data. Low alkali cements (less than 0.6% total equivalent alkalinity) should be specified when any doubt exists.

Do not use cement that is partially set or contains lumps of caked cement. Do not use cement salvaged from discarded or used bags.

501–2.3 CEMENTITIOUS MATERIALS.

a. Fly Ash. Fly ash shall meet the requirements of ASTM C 618, Class C or F with the exception of loss of ignition, where the maximum shall be less than 6 percent for Class F. When reactive cements or aggregates are used in the concrete, supplementary optional chemical and physical properties of Tables 1A and 2A contained in ASTM C 618 shall apply.

b. Blast Furnace Slag. Ground blast furnace slag shall meet the requirements of ASTM C 989, Grade 100 or 120.

NOTE TO SPECIFIER:

Fly ash may be accepted from sources that are prequalified by other agencies such as the Division of Transportation, Infrastructure Development, Department of Transportation Division of Highways, provided it meets the loss of ignition requirement of this specification and is accompanied by a certification and test data.

501–2.4 PREMOLDED JOINT FILLER. Premolded joint filler for expansion joints shall conform to the requirements of ASTM D 1751 or ASTM D 1752, Type II or III, and shall be punched to admit the dowels where called for on the Plans. Unless otherwise specified by the Engineer, furnish the filler for each joint in a single piece for the full depth and width required for the joint. When the use of more than one piece is required for a joint, fasten the abutting ends securely and hold accurately to shape by stapling or other positive fastening means satisfactory to the Engineer.

NOTE TO SPECIFIER:

Joint filler must be compatible with joint sealants.

501-2.5 JOINT SEALER. The joint sealer for the joints in the concrete pavement shall meet the requirements of Specification P-605 and shall be of the type(s) specified in the Plans.

501-2.6 STEEL REINFORCEMENT. Reinforcing, when shown on the Plans, shall consist of welded steel wire fabric conforming to the requirements of ASTM A 185 or ASTM A 497. Provide either type unless a specific type is indicated on the Plans.

**NOTE TO SPECIFIER:
The FAA allows the following:**

Welded Steel Wire Fabric	ASTM A 185
Welded Deformed Steel Fabric	ASTM A 497
Bar Mats	ASTM A 184 or A 704

Welded wire fabric shall be furnished in flat sheets only.

Welded steel wire fabric was specified in the Standard Specifications; changes can be made by Special Provision.

501-2.7 DOWEL AND TIE BARS. Tie bars shall be deformed steel bars and conform to the requirements of ASTM A 615, ASTM A 616, or ASTM A 617, except that rail steel bars, Grade 50 or 60, shall not be used for tie bars that are to be bent or restraightened during construction. Tie bars designated as Grade 40 in ASTM A 615 can be used for construction requiring bent bars.

Dowel bars shall be plain steel bars conforming to ASTM A 615, ASTM A 616 or ASTM A 617 and shall be free from burring or other deformation restricting slippage in the concrete. High strength dowel bars shall conform to ASTM A 714, Class 2, Type S, Grade I, II or III, Bare Finish. Before delivery to the construction site paint each dowel bar on all surfaces with one coat of paint meeting Federal Specification TT-P-664. If plastic or epoxy-coated steel dowels are used no paint coating is required, except when specified for a particular situation on the Contract Plans. Coated dowels shall conform to the requirements of AASHTO M 254.

**NOTE TO SPECIFIER:
The designer should consider which dowel sizes and coating are commonly available locally in order to reduce delivery times and prices. 1- 1/4" and 1-1/2" dowels, 18 inches in length, are currently common sizes for highway projects. Epoxy coating is the standard on highway projects. It costs about 7 cents more per lineal foot of dowel than painting; however, it is more durable.**

The sleeves for dowel bars used in expansion joints shall be metal or other type of an approved design to cover 2 to 3 inches (50 mm to 75 mm) of the dowel, with a closed end and with a suitable stop to hold the end of the bar at least 1 inch (25 mm) from the closed end of the sleeve. Sleeves shall be designed so that they will not collapse during construction.

501-2.8 WATER. Water used in mixing or curing shall be clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product. Water will be tested in accordance with the requirements of AASHTO T 26. Water known to be of potable quality may be used without testing.

501-2.9 COVER MATERIAL FOR CURING. Curing materials shall conform to one of the following specifications:

- a. Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C 309, Type 2, Class B.
- b. White polyethylene film for curing concrete shall conform to the requirements of ASTM C 171.
- c. White burlap-polyethylene sheeting for curing concrete shall conform to the requirements of ASTM C 171.
- d. Waterproof paper for curing concrete shall conform to the requirements of ASTM C 171.

501-2.10 ADMIXTURES. The Engineer will approve the use of material added to the concrete mix. Submit certificates indicating that the material to be furnished meets all of the requirements indicated below. In addition, the Engineer may require the Contractor to submit complete test data from an approved laboratory showing that the material to be furnished meets all of the requirements of the cited specifications. Subsequent tests may be made of samples taken by the Engineer from the supply of material being furnished or proposed for use on the Work to determine whether the admixture is uniform in quality with that approved.

a. **Air-Entraining Admixtures.** Air-entraining admixtures shall meet the requirements of ASTM C 260 and shall consistently entrain the air content in the specified ranges under field conditions. The air-entrainment agent and chemical admixtures shall be compatible.

b. Chemical Admixtures. Water-reducing, set retarding, and set-accelerating admixtures shall meet the requirements of ASTM C 494, including the flexural strength test.

501-2.11 EPOXY-RESIN. Epoxy-resin used to anchor dowels and tie bars in pavements shall conform to the requirements of ASTM C 881, Type I, Grade 3, Class C. Class A or B shall be used when the surface temperature of the hardened concrete is below 60°F (16°C).

501-2.12 MATERIAL ACCEPTANCE. Prior to use of materials, submit certified test reports to the Engineer for those materials proposed for use during construction. The certification shall show the appropriate ASTM test(s) for each material, the test results, and a statement that the material passed or failed.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

MIX DESIGN

501-3.1 PROPORTIONS. Design concrete to achieve a 28-day flexural strength so that not more than 20 percent of the concrete produced will fall below a flexural strength of 650 psi (4480 kPa). Design the mix using the procedures contained in Chapter 7 of the Portland Cement Association's Manual, "Design and Control of Concrete Mixtures."

NOTE TO SPECIFIER:

The design flexural strength was specified as 650 psi (4480 kPa) in the Standard Specifications. The minimum flexural strength allowable for airport pavements is 600 psi (4136 kPa). The design strength can be modified by Special Provision upon approval by WBOA.

Higher flexural strength can be specified when local materials make this economically feasible. However, it must be recognized that due to variations in materials, operations, and testing the average strength of concrete furnished by a supplier must be substantially above the specified strength to insure a good statistical chance of meeting the acceptance criteria throughout the duration of the job.

For pavements designed to accommodate aircraft gross weights of 30,000 pounds (13 600 kg) or less, this section may be modified to indicate that concrete shall be designed to achieve a 28 day compressive strength such that not more than 20 percent of the concrete produced will fall below the design compressive strength of 4,400 psi (30 300 kPa).

If the specified strength is required earlier than 28 days, the Engineer shall designate the time period.

To ensure that not more than 20 percent of the concrete actually produced will fall below the specified strength, the mix design average strength must be considerably higher than the specified strength. The amount of overdesign necessary to meet specification requirements depends on the producer's standard deviation of flexural test results and the accuracy which that value can be estimated from historic data for the same or similar materials. The minimum cementitious material (cement plus fly ash) shall be 500 pounds per cubic yard (297 kg per cubic meter). The ratio of water to cementitious material, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates shall not be more than 0.50 by weight.

NOTE TO SPECIFIER:

A minimum cement content of 500 pounds (227 kg) was specified in the Standard Specifications. A higher minimum may be necessary to meet the specified strength when other cementitious materials are substituted or to meet durability requirements for severe freeze/thaw, deicer, or sulfate exposure.

A maximum water/cementitious ratio of 0.50 was specified in the Standard Specifications. A lower water/cementitious material ratio may be necessary for severe freeze/thaw, deicer, or sulfate exposure.

Prior to the start of paving operations and after approval of all material to be used in the concrete, submit a mix design showing the proportions and flexural strength obtained from the concrete at 7 and 28 days. Include with the mix design copies of test reports, including test dates, and a complete list of materials including type, brand, source, and amount of cement, fly ash, ground slag, coarse aggregate, fine aggregate, water, and admixtures. Show the fineness modulus of the fine aggregate and the air content. Submit the mix design to the Engineer at least 15 days prior to the start of operations. Do not begin production until the mix design is approved in writing by the Engineer.

Should a change in sources be made, or admixtures added or deleted from the mix, submit a new mix design must be submitted to the Engineer for approval.

NOTE TO SPECIFIER:

A minimum of 10 days was included in the Standard Specification. A longer time may be required by Special Provision. The Engineer may specify that previously approved mix designs older than 90 days shall not be used.

Flexural strength test specimens shall be prepared in accordance with ASTM C 31 and tested in accordance with ASTM C 78. The mix determined shall be workable concrete having a slump for side-form concrete between 1 and 2 inches (25 mm and 50 mm) as determined by ASTM C 143. For vibrated slip-form concrete, the slump shall be between 1/2 inch (13 mm) and 1 1/2 inches (38 mm).

NOTE TO SPECIFIER:

If the basis of the design strength in paragraph 501-3.1 is changed by Special Provision to compressive strength, the specimens should be tested in accordance with ASTM C 39. Substitute "compressive strength" for "flexural strength" in appropriate sections of the Specification.

501-3.2 CEMENTITIOUS MATERIALS.

a. Fly Ash. Fly ash may be used in the mix design. When fly ash is used as a partial replacement for cement, the minimum cement content may be met by considering Portland cement plus fly ash as the total cementitious material. The replacement rate shall be determined from laboratory trial mixes, but shall not exceed 20 percent by weight of the total cementitious material.

b. Ground Slag. Ground blast-furnace slag may be used in a mix design containing Type I or Type II cement. The slag, or slag plus fly ash if both are used, may constitute between 25 to 55 percent of the total cementitious material by weight. If the concrete is to be used for slipforming operations and the air temperature is expected to be lower than 55°F (13°C) the percent slag shall not exceed 30 percent by weight.

NOTE TO SPECIFIER:

The percentage of fly ash allowed in the mix was specified as 20% of total cementitious material in the Standard Specifications.

Due to variations in fly ash, cement, strength requirements, etc. the replacement rate specified can be changed by Special Provision based on local materials, but should be between 10-20 percent.

Concrete containing fly ash will ultimately develop a flexural strength greater than concrete without fly ash. However, the rate of development and the ultimate strength of the concrete depends on the characteristics of the fly ash, the cement used, the proportions of fly ash and cement, and the curing environment.

EPA guidelines published in 40 CFR Part 249, which implement provisions of the Resource Conservation and Recovery Act of 1976, require that contract specifications allow for the use of fly ash, unless its use can be determined to be inappropriate for technical reasons documented by the Owner or the design Engineer.

501-3.3 ADMIXTURES.

a. Air-Entraining. Add air-entraining admixture so that it will insure uniform distribution of the agent throughout the batch. Base the air content of freshly mixed air-entrained concrete on trial mixes with the materials to be used in the work adjusted to produce concrete of the required plasticity and workability. The percentage of air in the mix is 6 percent. Determine air content by testing in accordance with ASTM C 231 for gravel and stone coarse aggregate and ASTM C 173 for slag and other highly porous coarse aggregate.

b. Chemical. Add water-reducing, set-controlling, and other approved admixtures to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Conduct tests on trial mixes, with the materials to be used in the Work, in accordance with ASTM C 494.

NOTE TO SPECIFIER:

Six percent air was specified in the Standard Specification. Changes can be made by Special Provisions based upon the following FAA recommendations. For warm climate areas where freezing and thawing is not a factor, non-air-entrained concrete may be used.

**RECOMMENDED AIR CONTENT (PERCENT
Maximum Size Aggregate**

Mild exposure – When desired for other than durability, such as to improve workability. Used where pavement will not be exposed to freezing or to deicing agents.

Moderate exposure – Service in a climate where freezing is expected but where the concrete will not be continually exposed to moisture or free water for long periods prior to freezing and will not be exposed to deicing agents or other aggressive chemicals.

Severe exposure – Concrete which is exposed to deicing chemicals or other aggressive agents or where the concrete may become highly saturated by continual contact with moisture or free water prior to freezing.

501–3.4 TESTING LABORATORY. The laboratory used to develop the mix design shall meet the requirements of ASTM C 1077. Submit a certification that it meets these requirements to the Engineer prior to the start of mix design and it should contain as a minimum:

- a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.
- b. A statement that the equipment used in developing the mix design is in calibration.
- c. A statement that each test specified in developing the mix design is offered in the scope of the laboratory's services.
- d. A copy of the laboratory's quality control system.

CONSTRUCTION METHODS

501–4.1 EQUIPMENT. Furnish all equipment and tools necessary for handling materials and performing all parts of the Work.

- a. **Batch Plant and Equipment.** The batch plant and equipment shall conform to the requirements of ASTM C 94.
- b. **Mixers and Transportation Equipment.**

(1) **General.** Concrete may be mixed at a central plant, or wholly or in part in truck mixers. Each mixer shall have attached (in a prominent place) a manufacturer's nameplate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

NOTE TO SPECIFIER:

The Engineer may specify by Special Provision the use of a central plant mixer if deemed necessary for a particular project.

(2) **Central Plant Mixer.** Central plant mixers shall conform to the requirements of ASTM C 94.

Examine the mixer daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades. Replace the pickup and throwover blades when they have worn down 3/4 inch (19 mm) or more. The Contractor shall have a copy of the manufacturer's design on hand showing dimensions and arrangement of blades in reference to original height and depth.

(3) **Truck Mixers and Truck Agitators.** Truck mixers used for mixing and hauling concrete and truck agitators used for hauling central-mixed concrete shall conform to the requirements of ASTM C 94.

(4) **Nonagitator Trucks.** Nonagitating hauling equipment shall conform to the requirements of ASTM C 94.

c. **Finishing Equipment.** The finishing equipment shall be of sufficient weight and power for proper finishing of the concrete. The finishing machine shall be designed and operated to strike off, screed, and consolidate the concrete so that laitance on the surface is less than 1/8-inch (3 mm) thick.

d. **Vibrators.** Vibrators shall be either internal type with immersed tube or multiple spuds, or surface type vibrating pan or screed. For pavements 8 inches (200 mm) or more thick, internal vibrators shall be used. They may be attached to the spreader or the finishing machine, or they may be mounted on a separate carriage. Use an operating frequency for internal vibrators between 8,000 and 12,000 vibrations per minute. Average amplitude for internal vibrators shall be 0.025–0.05 inches (0.6 – 1.3 mm). For pavements less than 8 inches (200 mm) thick, vibrating surface pans or screeds will be allowed. Operating frequencies for surface vibrators shall be between 3,000 and 6,000 vibrations per minute.

Set the number, spacing, and frequency to provide a dense and homogeneous pavement. Provide adequate power to operate all vibrators on the paver. The vibrators shall be automatically controlled so that they shall be stopped as forward motion ceases.

Hand held vibrators may be used in irregular areas.

e. **Concrete Saws.** Provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions. Provide at least one standby saw in good working order and a supply of saw blades at the site of the Work at all times during sawing operations.

f. Side Forms. Straight side forms shall be made of steel and shall be furnished in sections not less than 10 feet (3 m) in length. Forms shall have a depth equal to the pavement thickness at the edge. Flexible or curved forms of proper radius shall be used for curves of 100-foot (30 m) radius or less. Provide forms with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Do not use forms with battered top surfaces and bent, twisted or broken forms. Do not use built-up forms, except as approved by the Engineer. The top face of the form shall not vary from a true plane more than 1/8 inch (3 mm) in 10 feet (3 m), and the upstanding leg shall not vary more than 1/4 inch (6 mm). The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when approved by the Engineer.

g. Pavers. Use a paver that will be fully energized, self-propelled, and designed for the specific purpose of placing, consolidating, and finishing the concrete pavement, true to grade, tolerances, and cross section. It must be of sufficient weight and power to construct the maximum specified concrete paving lane width as shown in the Plans, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. Equip the paver with electronic or hydraulic horizontal and vertical control devices.

501-4.2 FORM SETTING. Set forms sufficiently in advance of the concrete placement to insure continuous paving operation. After the forms have been set to correct grade, thoroughly tamp the underlying surface, either mechanically or by hand, at both the inside and outside edges of the base of the forms. Stake forms into place sufficiently to maintain the form in position for the method of placement.

Tightly lock form sections to be free from play or movement in any direction. The forms cannot deviate from true line by more than 1/8 inch (3 mm) at any joint. Set forms so that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Clean and oil forms prior to the placing of concrete.

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

501-4.3 CONDITIONING OF UNDERLYING SURFACE, SLIP-FORM CONSTRUCTION. Widen the compacted underlying surface on which the pavement will be placed approximately 3 feet (1 m) to extend beyond the paving machine track to support the paver without any noticeable displacement. After the underlying surface has been placed and compacted to the required density, trim or grade the areas which will support the paving machine and the area to be paved to the Plan grade elevation and profile by means of a properly designed machine. Control the grade of the underlying surface by a positive grade control system using lasers, stringlines, or guide wires. If the density of the underlying surface is disturbed by the trimming operations, correct it by additional compaction and retest it at the option of the Engineer before the concrete is placed, except when stabilized subbases are being constructed. If damage occurs on a stabilized subbase, correct it full depth. If traffic is allowed to use the prepared grade, check and correct the grade immediately before the placement of concrete. Moisten the prepared grade with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete. Protect the underlying surface so that it will be entirely free of frost when concrete is placed.

NOTE TO SPECIFIER:

Stabilized subbase is required to accommodate aircraft with gross weights in excess of 100,000 pounds (45,300 kg) per Advisory Circular 150/5320-6.

The typical sections on the Plans should show subgrade extending a minimum of 3 feet (1 m) beyond the concrete.

501-4.4 CONDITIONING OF UNDERLYING SURFACE, SIDE-FORM AND FILL-IN LANE CONSTRUCTION. Moisten the prepared underlying surface with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete. Correct and retest damage caused by hauling or usage of other equipment at the option of the Engineer. If damage occurs to a stabilized subbase, correct it full depth. Provide and operate a template on the forms immediately in advance of the placing of all concrete. Propel the template by hand only and do not attach to a tractor or other power unit. Adjust templates so that they may be set and maintained at the correct contour of the underlying surface. Adjust and operate the templates to provide an accurate retest of the grade before placing the concrete thereon. Remove and waste all excess fill and compact low areas to a condition similar to that of the surrounding grade. Protect the underlying surface so that it will be entirely free from frost when the concrete is placed. The use of chemicals to eliminate frost in the underlying surface is not permitted.

Maintain the template in accurate adjustment, at all times and check it daily.

501-4.5 HANDLING, MEASURING, AND BATCHING MATERIAL. The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the Work. Construct stockpiles in a manner that prevents segregation and intermixing of deleterious materials.

Do not use aggregates that have become segregated or mixed with earth or foreign material. Stockpile or bin for draining all aggregates produced or handled by hydraulic methods, and washed aggregates, at least 12 hours before being batched. Rail shipments requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage.

Equip batching plants to proportion aggregates and bulk cement, by weight, automatically using interlocked proportioning devices of an approved type. When bulk cement is used, use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, such as a chute, boot, or other approved device, to prevent loss of cement. Arrange the device to provide positive assurance that the cement content specified is present in each batch.

501-4.6 MIXING CONCRETE. The concrete may be mixed at the Work site, in a central mix plant or in truck mixers. The mixer shall be of an approved type and capacity. Measure mixing time from the time all materials, except water, are emptied into the drum. Mix and deliver all concrete to the site in accordance with the requirements of ASTM C 94. Transport mixed concrete from the central mixing plant in truck mixers, truck agitators, or nonagitator trucks. The elapsed time from the addition of cementitious material to the mix until the concrete is deposited in place at the Work site shall not exceed 30 minutes when the concrete is hauled in nonagitator trucks, and shall not exceed 90 minutes when the concrete is hauled in truck mixers or truck agitators. Retempering concrete by adding water or by other means will not be permitted, except when concrete is delivered in transit mixers. With transit mixers additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements provided the addition of water is performed within 45 minutes after the initial mixing operations and provided the water/cementitious ratio specified in the mix design is not exceeded.

501-4.7 LIMITATIONS ON MIXING AND PLACING. Do not mix, place, or finish concrete when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

a. Cold Weather. Unless authorized in writing by the Engineer, discontinue mixing and concreting operations when a descending air temperature in the shade and away from artificial heat reaches 40°F (4°C), and do not resume the operations until an ascending air temperature in the shade and away from artificial heat reaches 35°F (2°C).

The aggregate shall be free of ice, snow, and frozen lumps before entering the mixer. The temperature of the mixed concrete shall not be less than 50°F (10°C) at the time of placement. Do not place concrete on frozen material and do not use frozen aggregates in the concrete.

When concreting is authorized during cold weather, water and/or the aggregates may be heated to not more than 150°F (66°C). Heat the mass uniformly and arrange the heating apparatus to preclude the possible occurrence of overheated areas that might be detrimental to the materials.

NOTE TO SPECIFIER:

Information regarding cold weather concreting practices may be found in ACI 306R, Cold Weather Concreting.

b. Hot Weather. During periods of hot weather when the maximum daily air temperature exceeds 85°F (30°C), take the following precautions:

- (1) Sprinkle the forms and/or the underlying surface with water immediately before placing the concrete. Place the concrete at the coolest temperature practicable, and never allow the temperature of the concrete when placed to exceed 95°F (35°C). Cool the aggregates and/or mixing water as necessary to maintain the concrete temperature at or not more than the specified maximum.
- (2) Keep the finished surfaces of the newly laid pavement damp by applying a water-fog or mist with approved spraying equipment until the pavement is covered by the curing medium. If necessary, provide wind screens to protect the concrete from an evaporation rate in excess of 0.2 psf (.97 kg/m²) per hour as determined in accordance with Figure 2.1.5 in ACI 305R, Hot Weather Concreting, which takes into consideration relative humidity, wind velocity, and air temperature.
- (3) When conditions exist that problems with plastic cracking can be expected, and particularly if plastic cracking begins to occur, immediately take additional measures as necessary to protect the concrete surface. These measures shall consist of wind screens, more effective fog sprays, and similar measures starting immediately behind the paver. If these measures are not effective in preventing plastic cracking, stop paving operations immediately.

501-4.8 PLACING CONCRETE. Side (fixed) form or slip-form paving is optional. During concrete conveyance, the free vertical drop of the concrete from one point to another or to the underlying surface shall not exceed 3 feet (1 m).

Hauling equipment or other mechanical equipment can be permitted on adjoining previously constructed pavement when the concrete strength reaches a flexural strength of 550 psi (3,790 kPa) or a compressive strength of 3,500 psi (24,130 kPa), based on the average of four field cured specimens per 2,000 cubic yards (1,530 m³) of concrete placed. Subgrade and subbase planers, concrete pavers, and concrete finishing equipment may be permitted to ride upon the edges of previously constructed pavement when the concrete has attained a minimum flexural strength of 400 psi (2,760 kPa) or a compressive strength of 2,000 psi (13,790 kPa), based on the average of four field cured specimens per 2,000 cubic yards (1,530 m³) of concrete placed.

NOTE TO SPECIFIER:

The Engineer may specify either side form or slip-form method of paving or allow the Contractor the option as indicated in the Standard Specification.

Select either of the following paving methods:

a. Side-form Method. For the side-form method, deposit the concrete on the moistened grade to require as little rehandling as possible. Unless truck mixers, truck agitators, or nonagitator hauling equipment are equipped with means for discharge of concrete without segregation of the materials, place and spread the concrete using an approved mechanical spreading device that prevents segregation of the materials. Continuously place

the concrete between transverse joints without the use of intermediate bulkheads. Do necessary hand spreading with shovels. Do not use rakes for spreading. Do not allow workers to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.

Deposit concrete as near to expansion and contraction joints as possible without disturbing them, but do not dump the concrete from the discharge bucket or hopper onto a joint assembly unless the hopper is centered above the joint assembly.

Thoroughly consolidate concrete against and along the faces of all forms and previously placed concrete and along the full length and on both sides of all joint assemblies by means of vibrators inserted in the concrete. Vibrators cannot come in contact with a joint assembly, the grade, or a side form. Never operate the vibrator longer than 20 seconds in any one location, never allow the vibrators be used to move the concrete.

b. Slip-form Method. For this method, place the concrete with an approved crawler-mounted, slip-form paver designed to spread, consolidate, and shape the freshly placed concrete in one complete pass of the machine so that a minimum of hand finishing will be necessary to provide a dense and homogeneous pavement in conformance with requirements of the Plans and Specifications. Place the concrete directly on top of the joint assemblies to prevent them from moving when the paver moves over them. Side forms and finishing screeds shall be adjustable to the extent required to produce the specified pavement edge and surface tolerance. The side forms shall be of dimensions, shape, and strength to support the concrete laterally for a sufficient length of time so that no edge slumping exceeds the requirements of Paragraph 501-5.2e(5). Accomplish final finishing while the concrete is still in the plastic state.

In the event that slumping or sloughing occurs behind the paver or if there are any other structural or surface defects which, in the opinion of the Engineer, cannot be corrected within permissible tolerances, immediately stop paving operations until proper adjustment of the equipment or procedures have been made. In the event that satisfactory procedures and pavement are not achieved after not more than 2,000 linear feet (600 m) of single lane paving, complete the balance of the Work with the use of standard metal forms and the formed method of placing and curing. Remove and replace concrete not corrected to permissible tolerances at the Contractor's expense.

501-4.9 STRIKE-OFF OF CONCRETE AND PLACEMENT OF REINFORCEMENT. Following the placing of the concrete, strike it off to conform to the cross section shown on the Plans and to an elevation so that when the concrete is properly consolidated and finished, the surface of the pavement shall be at the elevation shown on the Plans. When reinforced concrete pavement is placed in two layers, strike off the bottom layer to a length and depth that the sheet of reinforcing steel fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. Next place the reinforcement directly upon the concrete, and then place the top layer of the concrete, struck off, and screeded. Remove and replace (at the Contractor's expense) portions of the bottom layer of concrete with freshly mixed concrete if the bottom layer of concrete is placed more than 30 minutes without being covered with the top layer or if initial set has taken place. When reinforced concrete is placed in one layer, the reinforcement may be positioned in advance of concrete placement or it may be placed in plastic concrete by mechanical or vibratory means after spreading.

Reinforcing steel, at the time concrete is placed, shall be free of mud, oil, or other organic matter that may adversely affect or reduce bond. Reinforcing steel with rust, mill scale, or a combination of both will be considered satisfactory, provided the minimum dimensions, weight, and tensile properties of a hand wire-brushed test specimen are not less than the applicable ASTM specification requirements.

501-4.10 JOINTS. Construct joints as shown on the Plans and in accordance with these requirements. Construct all joints with their faces perpendicular to the surface of the pavement and finished or edged as shown on the Plans. Do not vary joints more than 1/2 inch (13 mm) from their designated position and ensure that they are true to line with not more than 1/4-inch (6 mm) variation in 10 feet (3 m). Test the surface across the joints with a Contractor furnished 10-foot (3 m) straightedge as the joints are finished and correct irregularities in excess of 1/4 inch (6 mm) before the concrete has hardened. Prepare, finish, or cut all joints to provide a groove of uniform width and depth as shown on the Plans.

a. Construction. Slip form or form longitudinal construction joints against side forms with or without keyways, as shown in the Plans.

Install transverse construction joints at the end of each day's placing operations and at other points within a paving lane when concrete placement is interrupted for more than 30 minutes or it appears that the concrete will obtain its initial set before fresh concrete arrives. Install the joint at a planned contraction or expansion joint. If placing of the concrete is stopped, remove the excess concrete back to the previous planned joint.

b. Contraction. Install contraction joints at the locations and spacing as shown on the Plans. Install contraction joints to the dimensions required by forming a groove or cleft in the top of the slab while the concrete is still plastic or by sawing a groove into the concrete surface after the concrete has hardened. When the groove is formed in plastic concrete finish the sides of the grooves even and smooth with an edging tool. If an insert material is used, the installation and edge finish shall be according to the manufacturer's instructions. Finish or cut clean the groove so that spalling will be avoided at intersections with other joints. Grooving or sawing shall produce a slot at least 1/8 inch (3 mm) wide and to the depth shown on the Plans.

c. Expansion. Install expansion joints as shown on the Plans. Extend the premolded filler of the thickness as shown on the Plans, for the full depth and width of the slab at the joint, except for space for sealant at the top of the slab. Securely stake or fasten the filler into position perpendicular to the proposed finished surface. Provide a cap to protect the top edge of the filler and to permit the concrete to be placed and finished. After the concrete has been placed and struck off, carefully withdraw the cap leaving the space over the premolded filler. Finish and tool the edges of the joint while the concrete is still plastic. Remove concrete bridging the joint space for the full width and depth of the joint.

NOTE TO SPECIFIER:

An expansion joint is primarily used as an isolation joint to separate structures with different foundations and pavements with different joint patterns. It does not provide for expansion by the material compressing, but rather allowing the joint to slip. There should rarely be an occasion to dowel an expansion joint since it defeats the purpose of the joint and does not permit isolation and slippage. A thickened-edge is the preferred load transfer method for expansion joints.

Keywords. Form keyways in the plastic concrete by means of side forms or the use of keyway liners which are inserted during the slip-form operations. Form the keyway to a tolerance of 1/4 inch (6 mm) in any dimension and ensure it to be of sufficient stiffness to support the upper keyway flange without distortion or slumping of the top of the flange. The dimensions of the keyway forms shall not vary more than plus or minus 1/4 inch (6 mm) from the mid-depth of the pavement. Liners that remain in place permanently and become part of the keyed joint shall be made of galvanized, copper clad, or of similar rust-resistant material compatible with plastic and hardened concrete and shall not interfere with joint reservoir sawing and sealing.

NOTE TO SPECIFIER:

The Engineer should refer to Advisory Circular 150/5320-6 for guidance on the use of keyways.

e. Tie Bars. Tie bars shall consist of deformed bars installed in joints as shown on the Plans. Place tie bars at right angles to the centerline of the concrete slab and space at intervals shown on the Plans. Hold them in position parallel to the pavement surface and in the middle of the slab depth. When tie bars extend into an unpaved lane, they may be bent against the form at longitudinal construction joints, unless threaded bolt or other assembled tie bars are specified. Do not paint, grease, or enclose sleeves in the bars. When slip-form operations call for tie bars, two-piece hook bolts can be installed in the female side of the keyed joint provided the installation is made without distorting the keyed dimensions or causing edge slump. If a bent tie bar installation is used, insert the tie bars through the keyway liner only on the female side of the joint. Using a bent tie bar installation for male keyways is not permitted.

f. Dowel Bars. Place dowel bars or other load-transfer units of an approved type across joints in the manner as shown on the Plans. They shall be of the dimensions and spacings as shown and held rigidly in the middle of the slab depth in the proper horizontal and vertical alignment by an approved assembly device to be left permanently in place. The dowel or load-transfer and joint devices shall be rigid enough to permit complete assembly as a unit ready to be lifted and placed into position. Furnish a metal, or other type, dowel expansion cap or sleeve for each dowel bar used with expansion joints. These caps shall be substantial enough to prevent collapse and shall be placed on the ends of the dowels as shown on the Plans. The caps or sleeves shall fit the dowel bar tightly and the closed end shall be watertight. Thoroughly coat the portion of each dowel painted with rust preventative paint, as required under paragraph 501-2.7, with asphalt MC-70, or an approved lubricant, to prevent the concrete from bonding to that portion of the dowel. If free-sliding plastic-coated or epoxy-coated steel dowels are used, use a lubrication bond breaker except when approved pullout tests indicate it is not necessary. Where butt-type joints with dowels are designated, oil the exposed end of the dowel.

Dowel bars at contraction joints may be placed in the full thickness of pavement by a mechanical device approved by the Engineer. The device shall be capable of installing dowel bars within the maximum permissible alignment tolerances. Bond dowel bars at longitudinal construction joints in drilled holes.

g. Installation of Joint Devices. All joint devices shall be approved by the Engineer.

Set the top of an assembled joint device at the proper distance below the pavement surface and check the elevation. Set these devices to the required position and line and securely hold them in place by stakes or other means to the maximum permissible tolerances during the placing and finishing of the concrete. Where premolded joint material is used, place and hold it in a vertical position. If it is constructed in sections, there shall be no offsets between adjacent units.

Check dowel bars and assemblies for position and alignment. The maximum permissible tolerances on dowel bar alignment shall be in accordance with Paragraph 501-5.2e(6). During the concrete placement operation, it is advisable to place plastic concrete directly on dowel assemblies immediately prior to passage of the paver to help maintain dowel position and alignment within maximum permissible tolerances.

When concrete is placed using slip-form pavers, place dowels and tie bars in longitudinal construction joints by bonding the dowels or tie bars into holes drilled into the hardened concrete. Drill holes approximately 1/8-inch to 1/4-inch (3 to 6 mm) greater in diameter than the dowel or tie bar with rotary-type core drills that must be held securely in place to drill perpendicularly into the vertical face of the pavement slab. Rotary-type percussion drills may be used provided that spalling of concrete does not occur. Repair damage to the concrete in a method approved by the Engineer. Bond dowels or tie bars in the drilled holes using an epoxy resin material. Use adequate installation procedures to insure that the area around dowels is completely filled with epoxy grout. Inject epoxy into the back of the hole and displace it by the insertion of the dowel bar. Completely insert bars into the hole and do not withdraw and reinsert. Furnish a template for checking the position and alignment of the dowels. Dowel bars shall not be less than 10 inches (250 mm) from a transverse joint and shall not interfere with dowels in the transverse direction.

h. Sawing of Joints. Cut joints as shown on the Plans. Equipment shall be as described in Paragraph 501-4.1. Use a circular cutter that is capable of cutting a groove in a straight line and can produce a slot at least 1/8 inch (3 mm) wide and to the depth shown on the Plans. Widen the top portion of the slot by sawing to provide adequate space for joint sealers as shown on the Plans. Commence sawing as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing and before uncontrolled shrinkage cracking of the pavement occurs. Sawing can be done both during the day and night as required. Saw the joints at the required spacing, consecutively in sequence of the concrete placement.

501-4.11 FINAL STRIKE-OFF, CONSOLIDATION, AND FINISHING.

a. Sequence. The sequence of operations is the strike-off, floating and removal of laitance, straightedging, and final surface finish. Do not add superficial water to the surface of the concrete to assist in finishing operations.

b. Finishing at Joints. Compact and firmly place the concrete adjacent to joints without voids or segregation against the joint material. Firmly place it without voids or segregation under and around all load-transfer devices, joint assembly units, and other features designed to extend into the pavement. Mechanically vibrate concrete adjacent to joints as required in Paragraph 501-4.8a. After the concrete has been placed and vibrated adjacent to the joints, operate the finishing machine to avoid damage or misalignment of joints. If uninterrupted operations of the finishing machine, to, over, and beyond the joints, cause segregation of concrete, damage to, or misalignment of the joints, stop the finishing machine when the screed is approximately 8 inches (200 mm) from the joint. Remove segregated concrete from the front of and off the joint; and resume the forward motion of the finishing machine. Thereafter, the finishing machine may be run over the joint without lifting the screed, provided there is no segregated concrete immediately between the joint and the screed or on top of the joint.

c. Machine Finishing. Spread the concrete as soon as it is placed, and strike it off and screed it by using a finishing machine. Go over each area as many times and as often as necessary to give proper consolidation and to leave a surface of uniform texture. Avoid excessive operation over a given area. When side forms are used, keep the tops of the forms clean by using an effective device attached to the machine, and maintain the travel of the machine on the forms true without lift, wobbling, or other variation tending to affect the precision finish. During the first pass of the finishing machine, maintain a uniform ridge of concrete ahead of the front screed for its entire length. When in operation, move the screed forward with a combined longitudinal and transverse shearing motion, always moving in the direction in which the Work is progressing, and so manipulated that neither end is raised from the side forms during the striking-off process. If necessary, repeat this until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

d. Hand Finishing. Hand finishing methods are not permitted, except under the following conditions:

- (1) In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade;
- (2) In areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical.

Strike off and screed concrete, as soon as it is placed. Use an approved portable screed. Provide a second screed for striking off the bottom layer of concrete when reinforcement is used.

The screed for the surface shall be at least 2 feet (0.6 m) longer than the maximum width of the slab to be struck off. It shall be of approved design, sufficiently rigid to retain its shape, and shall be constructed either of metal or of other suitable material covered with metal. Attain consolidation by the use of suitable vibrators.

e. Floating. After the concrete has been struck off and consolidated, smooth and true it by means of a longitudinal float using one of the following methods:

(1) Hand Method. Long-handled floats shall not be less than 12 feet (3.6 m) in length and 6 inches (150 mm) in width, stiffened to prevent flexibility and warping. Operate the float from foot bridges spanning but not touching the concrete or from the edge of the pavement. Floating shall pass gradually from one side of the pavement to the other. Forward movement along the centerline of the pavement shall be in successive advances of not more than one-half the length of the float. Remove and waste excess water or laitance in excess of 1/8-inch (3 mm) thick.

(2) Mechanical Method. The Contractor may use a machine composed of a cutting and smoothing float(s), suspended from and guided by a rigid frame and constantly in contact with the side forms or underlying surface. If necessary, long-handled floats having blades not less than 5 feet (1.5 m) in length and 6 inches (150 mm) in width may be used to smooth and fill in open-textured areas in the pavement. When the crown of the pavement will not permit the use of the mechanical float, float the surface transversely by means of a long-handled float. Take care not to work the crown out of the pavement during the operation. After floating, remove and waste any excess water and laitance in excess of 1/8-inch (3 mm) thick. Lap successive drags one-half the length of the blade.

f. Straight-edge Testing and Surface Correction. After the pavement has been struck off and while the concrete is still plastic, test it for trueness with a Contractor furnished 16-foot (4.9 m) straightedge swung from handles 3 feet (1 m) longer than one-half the width of the slab. Hold the straightedge in contact with the surface in successive positions parallel to the centerline and go over the whole area from one side of the slab to the other, as necessary. Advancing shall be in successive stages of not more than one-half the length of the straightedge. Remove and waste water and laitance in excess of 1/8-inch (3 mm) thick from the surface of the pavement. Immediately fill depressions with freshly mixed concrete, struck off, consolidated, and refinished. Cut down and refinish high areas. Give special attention to assure that the surface across joints meets the smoothness requirements of Paragraph 501-5.2e(3). Continue straightedge testing and surface corrections until the entire surface is found to be free from observable departures from the straightedge and until the slab conforms to the required grade and cross section. Confine the use of long-handled wood floats to a minimum. They may be used only in emergencies and in areas not accessible to finishing equipment.

501-4.12 SURFACE TEXTURE. Finish the surface of the pavement with either a broom, burlap drag, or artificial turf finish for all newly constructed concrete pavements.

a. Brush or Broom Finish. If the pavement surface texture is to be a type of brush or broom finish, apply it when the water sheen has practically disappeared. Operate the equipment transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 1/16 of an inch (2 mm) in depth. It is important that the texturing equipment not tear or unduly roughen the pavement surface during the operation. Correct imperfections resulting from the texturing operation.

b. Burlap Drag Finish. If a burlap drag is used to texture the pavement surface, it shall be at least 15 ounces per square yard (510 g/m²). To obtain a textured surface, remove the transverse threads of the burlap approximately 1 foot (0.3 m) from the trailing edge. A heavy buildup of grout on the burlap threads produces the desired wide sweeping longitudinal striations on the pavement surface. The corrugations should be uniform in appearance and approximately 1/16 of an inch (2 mm) in depth.

c. Artificial Turf Finish. If artificial turf is used to texture the surface, apply it by dragging the surface of the pavement in the direction of concrete placement with an approved full-width drag made with artificial turf. Securely fasten the leading transverse edge of the artificial turf drag to a lightweight pole on a traveling bridge. Have at least 2 feet (600 mm) of the artificial turf in contact with the concrete surface during dragging operations. A variety of different types of artificial turf are available, and approval of one type will be done only after it has been demonstrated by the Contractor to provide a satisfactory texture. One type that has provided satisfactory texture consists of 7,200 approximately 0.85-inch-long polyethylene turf blades per square foot. The corrugations should be uniform in appearance and approximately 1/16 of an inch (2 mm) in depth.

NOTE TO SPECIFIER:

The Engineer may specify a particular type of finish by Special Provision.

501-4.13 SKID RESISTANT SURFACES. Provide a skid resistant surface by construction of saw cut grooves or wire combing. Construct saw cut grooves when indicated in the Contract Documents.

SAW-CUT GROOVES. For new concrete pavements that have hardened, saw-cut transverse grooves in the pavement forming a 1/4 inch (6 mm) wide by 1/4 inch (6 mm) deep by 1-1/2 inches (37 mm) center-to-center configuration. Continue the grooves for the entire runway length. Saw-cut them transversely in the runway pavement to within 10 feet (3 m) of the runway pavement edge to allow adequate space for equipment operation. The maximum transverse saw-cut grooves shall not exceed 130 feet (40 m). Meet the following tolerances for the saw-cut grooves:

Alignment tolerance:

- Plus or minus 1-1/2 inches (38 mm) in alignment for 75 feet (23 m).

Groove tolerance:

- Minimum depth 3/16 inch (5 mm), except that not more than 60 percent of the grooves shall be less than 1/4 inch (6 mm).
- Maximum depth 5/16 inch (8 mm).
- Maximum width 5/16 inch (8 mm).

Center-to-center spacing:

- Minimum spacing 1-3/8 inches (35 mm)
- Maximum spacing 1-5/8 inches (38 mm).

Saw-cut grooves shall not be closer than 3 inches (76 mm) or more than 9 inches (229 mm) to transverse paving joints. Grooves shall not be closer than 6 inches (152 mm) and no more than 18 inches (457 mm) from in-pavement light fixtures. Grooves may be continued through longitudinal joints. Where neoprene compression seals have been installed, grooves shall not be closer than 3 inches (76 mm) or more than 5 inches (127 mm) from the longitudinal joints. Cleanup of waste material shall be continuous during the grooving operation. Dispose of waste material in an approved manner. Do not allow waste material to enter the airport storm or sanitary sewer system.

WIRE COMBING. Wire comb the concrete surface unless saw cut grooves are included in the Contract. Use steel combs or tines of various dimensions for the wire combing technique to form a groove-like texture in the plastic concrete pavement and provide grooves that are approximately 1/8 inch (3 mm) by 1/8 inch (3 mm) spaced 1/2 inch (13 mm) center-to-center. Construct the wire combing over the full pavement width. Operate the equipment transversely across the pavement surface perpendicular to the pavement centerline.

NOTE TO SPECIFIER:

When a skid-resistant surface is required in the design, the Engineer shall include a Pay Item for saw cut grooving for runway pavements and indicate the location on the Plans. In all cases, a surface texture shall be provided in the plastic concrete prior to construction of the skid-resistant surface. Wirecombing provides skid-resistance but does not prevent hydroplaning.

PLASTIC GROOVES. The grooves formed in the plastic concrete shall be 1/4 inch (6 mm) by 1/4 inch (6 mm) by 1-1/2 inches (38 mm). The grooves shall be continuous for the entire runway length and width. The tolerances for the grooves formed in plastic concrete shall meet the following:

Alignment tolerance.

Plus or minus 3 inches (76 mm) in alignment for 75 feet (23 m).

Groove tolerance.

Minimum depth 1/8 inch (3 mm)

Maximum depth 3/8 inch (10 mm).

Minimum width 1/8 inch (3 mm).

Maximum width 3/8 inch (10 mm).

Center-to-center spacing.

Minimum spacing 1-1/4 inches (32 mm).

Maximum spacing 2 inches (51 mm).

501-4.14 CURING. Immediately after finishing operations are completed and marring of the concrete will not occur, cure the entire surface of the newly placed concrete in accordance with one of the methods below. Failure to provide sufficient cover material of whatever kind the Contractor may elect to use, or lack of water to adequately take care of both curing and other requirements, will be cause for immediate suspension of concreting operations. Do not leave the concrete exposed for more than 1/2 hour during the curing period.

NOTE TO SPECIFIER:

The Engineer shall delete cure types that may not be feasible around aircraft jet blast in operating areas.

a. Impervious Membrane Method. Spray the entire surface of the pavement uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place. Do not apply the curing compound during rainfall. Apply curing compound by mechanical sprayers under pressure at the rate of 1 gallon (4 liters) to not more than 150 square feet (14 square meters). The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application stir the compound continuously by mechanical means. Hand spraying of odd widths or shapes and concrete surfaces exposed by the removal of forms is permitted. The curing compound should be of quality that the film will harden within 30 minutes after application. Should the film become damaged from any cause, including sawing operations, within the required curing period, repair the damaged portions immediately with additional compound or other approved means. Upon removal of side forms, protect the sides of the exposed slabs immediately to provide a curing treatment equal to that provided for the surface.

b. Polyethylene Films. Cover entirely the top surface and sides of the pavement entirely with polyethylene sheeting. Lap the units at least 18 inches (457 mm). Place and weight the sheeting causing it to remain in contact with the surface and sides. The sheeting dimensions must extend at least twice the thickness of the pavement beyond the edges of the pavement. Unless otherwise specified, maintain the sheeting in place for 7 days after the concrete has been placed.

c. Waterproof Paper. Cover the top surface and sides of the pavement entirely with waterproofed paper. Lap the units at least 18 inches (457 mm). Place and weight the paper causing it to remain in contact with the surface covered. The paper dimensions must extend at least twice the thickness of the pavement beyond the edges of the slab. Thoroughly saturate the surface of the pavement prior to placing of the paper. Unless otherwise specified, maintain the paper in place for 7 days after the concrete has been placed.

d. White Burlap-Polyethylene Sheets. Cover the surface of the pavement entirely with the sheeting. The sheeting used must extend at least twice the thickness of the pavement beyond the edges of the slab. Place the sheeting so that the entire surface and both edges of the slab are completely covered. Place and weigh the sheeting to remain in contact with the surface covered, and maintain the covering fully saturated and in position for 7 days after the concrete has been placed.

e. Curing in Cold Weather. Maintain the concrete at a temperature of at least 50°F (10°C) for a period of 72 hours after placing and at a temperature above freezing for the remainder of the curing time. Assume responsibility for the quality and strength of the concrete placed during cold weather. Remove and replace concrete injured by frost action at the Contractor's expense.

501-4.15 REMOVING FORMS. Unless otherwise specified, do not remove forms from freshly placed concrete until it has hardened sufficiently to permit removal without chipping, spalling, or tearing. After the forms have been removed, cure the sides of the slab as outlined in one of the methods

indicated in Paragraph 501–4.14. Consider major honeycombed areas as defective work and remove and replace it in accordance with Paragraph 501–5.2(f).

501–4.16 SEALING JOINTS. Seal the joints in the pavement in accordance with Specification P–605.

501–4.17 PROTECTION OF PAVEMENT. Protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents. This includes workers to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, crossovers, and protection of unsealed joints from intrusion of foreign material. Repair or replace damage to the pavement occurring prior to final acceptance at the Contractor's expense. Have available at all times, materials for the protection of the edges and surface of the unhardened concrete. These protective materials shall consist of rolled polyethylene sheeting at least 4 mils (0.1 mm) thick of sufficient length and width to cover the plastic concrete slab and any edges. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the plastic concrete surface. When rain appears imminent, stop all paving operations and have all available personnel begin covering the surface of the unhardened concrete with the protective covering.

501–4.18 OPENING TO TRAFFIC. Do not open the pavement to traffic until test specimens molded and cured in accordance with ASTM C 31 have attained a flexural strength of 550 pounds per square inch (3792 kPa) when tested in accordance with ASTM C 78, or a compressive strength of 3,500 psi (24,130 kPa) when tested in accordance with ASTM C 39. If these tests are not conducted, do not open the pavement to traffic until 14 days after the concrete was placed. Prior to opening to traffic, clean the pavement.

MATERIAL ACCEPTANCE

501–5.1 ACCEPTANCE SAMPLING AND TESTING. All acceptance sampling and testing, with the exception of coring for thickness determination, necessary to determine conformance with the requirements specified in this section will be performed by the Engineer. Concrete will be accepted for strength and thickness on a lot basis.

NOTE TO SPECIFIER:

On small projects it may be appropriate to define lots on a cubic yard basis. When this is the case, refer to the BOA Standard Special Provisions.

A lot shall consist of:

- One day's production not to exceed approximately 2,000 cubic yards (1,530 m³)
- A half day's production where a day's production is expected to consist of between approximately 2,000 cubic yards (1530 m³) and approximately 4,000 cubic yards (3,058 m³)
- Similar subdivisions for a day's production of over 4,000 cubic yards (3,058 m³)
- If a single day's production is expected to be less than approximately 1,000 cubic yards (765 m³) but more than approximately 500 cubic yards (382 m³), it will become two (2) sublots and added to the next lot, i.e., n=6.
- If a single day's production is expected to be less than approximately 500 cubic yards (382 m³), it will become one subplot for the next lot, i.e., n=5.

For projects where basis of payment is square yards, the Engineer will convert the lot size to an equivalent area.

Testing organizations performing these tests shall meet the requirements of ASTM C 1077. The Contractor shall bear the cost of providing curing facilities for the strength specimens, per Paragraph 501–5.1a(3), and coring and filling operations, per Paragraph 501–5.1b(1).

a. Flexural Strength.

(1) Sampling. Each lot shall be divided into 4 equal sublots. One (1) specimen will be taken for each subplot from the plastic concrete delivered to the job site. The Engineer will determine sampling locations in accordance with random sampling procedures contained in ASTM D 3665. The concrete will be sampled in accordance with ASTM C 172.

(2) Testing. Specimens will be made in accordance with ASTM C 31 and the flexural strength of each specimen shall be determined at 28 days in accordance with ASTM C 78.

(3) Curing. Provide adequate facilities for the initial curing of beams at the contractor's expense. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60° to 80°F (16° to 27°C), and loss of moisture from the specimens must be prevented. Store the specimens in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather or in heavyweight closed plastic bags, or use other suitable methods, provided the temperature and moisture loss requirements are met.

(4) Acceptance. The Engineer will determine acceptance of pavement for flexural strength in accordance with Paragraph 501–5.2b.

NOTE TO SPECIFIER:

Preventing loss of moisture is extremely important since relatively small amounts of surface drying of flexural specimens can induce tensile stresses in the extreme fibers that will markedly reduce the indicated flexural strength.

When the design strength in paragraph 501-3.1 is based on compressive strength, this paragraph should be revised as follows:

a. Compressive Strength.

(1) **Sampling.** Each lot shall be divided into four equal sublots. One (1) sample shall be taken for each subplot from the plastic concrete delivered to the job site. Sampling locations shall be determined by the Engineer in accordance with random sampling procedures contained in ASTM D 3665. The concrete shall be sampled in accordance with ASTM C 172.

(2) **Testing.** Specimens shall be made in accordance with ASTM C 31 and the compressive strength of each specimen shall be determined in accordance with ASTM C 39.

(3) **Curing.** The Contractor shall provide adequate facilities for the initial curing of cylinders. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60 to 80 degrees F (16 to 27 degrees C), and loss of moisture from the specimens must be prevented. The specimens may be stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather or in heavyweight closed plastic bags, or use other suitable methods, provided the temperature and moisture loss requirements are met.

b. Pavement Thickness.

(1) **Sampling.** Each lot as defined in Paragraph 501-5.1(a) will be divided into 4 equal sublots and one core shall be taken by the Contractor for each subplot. The Engineer will determine sampling locations in accordance with random sampling procedures contained in ASTM D 3665.

Cut cores neatly with a core drill. Furnish all tools, labor, and materials for cutting samples and filling the cored hole. Fill core holes with a non-shrink grout approved by the Engineer within one day after sampling.

(2) **Testing.** The Engineer will determine the thickness of the cores by the average caliper measurement in accordance with ASTM C 174.

(3) **Acceptance.** The Engineer will determine acceptance of pavement for thickness in accordance with Paragraph 501-5.2c.

c. Partial Lots. When operational conditions cause a lot to be terminated before the specified four tests have been made for the lot, the following procedure will be used to adjust the lot size and the number of tests for the lot.

Where three sublots have been produced, they will constitute a lot. Where one or two sublots have been produced, they will be incorporated into the next lot or the previous lot and the total number of sublots will be used in the acceptance criteria calculation, i.e., $n=5$ or $n=6$.

501-5.2 ACCEPTANCE CRITERIA.

a. General. Acceptance will be based on the following characteristics of the completed pavement:

- (1) Flexural strength
- (2) Thickness
- (3) Smoothness
- (4) Grade
- (5) Edge slump
- (6) Dowel bar alignment

Flexural strength will be evaluated for acceptance by the Engineer in accordance with Paragraph 501-5.2b. The Engineer will evaluate thickness for acceptance in accordance with Paragraph 501-5.2c. Smoothness will be evaluated by the Engineer in accordance with Paragraph 501-5.2e(3).

Acceptance for flexural strength and thickness will be based on the criteria contained in Paragraph 501–5.2e(1). Acceptance for thickness will be based on the criteria contained in Paragraph 501–5.2e(2). Acceptance for smoothness will be based on the criteria contained in Paragraph 501–5.2e(3). Acceptance for grade will be based on the criteria contained in Paragraph 501–5.2e(4).

The Engineer may at any time, notwithstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of concrete mixture which is rendered unfit for use due to contamination, segregation, or improper slump. The rejection may be based on only visual inspection. In the event of a rejection, the Contractor may take a representative sample of the rejected material in the presence of the Engineer, and if it can be demonstrated in the laboratory, in the presence of the Engineer, that the material was erroneously rejected, payment will be made for the material at the Contract unit price.

b. Flexural Strength. Acceptance of each lot of in-place pavement for flexural strength will be based on the percentage of material within specification limits (PWL). The PWL plan considers the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results.

NOTE TO SPECIFIER:

When the design strength in paragraph 501–3.1 is based on compressive strength, substitute compressive strength for flexural strength.

c. Pavement Thickness. Acceptance of each lot of in-place pavement will be based on the percentage of material within specification limits.

d. Percentage of Material Within Specification Limits (PWL). The percentage of material within specification limits will be determined in accordance with procedures specified in Section 110 of the General Requirements and Covenants.

The lower specification limit (L) for flexural strength and thickness will be:

Lower Specification Limit (L)

Flexural Strength Design strength given in Paragraph 501–3.1.

Thickness 0.97 x Plan thickness for the lot

NOTE TO SPECIFIER:

When the design strength in paragraph 501–3.1 is based on compressive strength, substitute compressive strength for flexural strength.

e. Acceptance Criteria.

(1) **Flexural Strength.** If the PWL of the lot equals or exceeds 80 percent for flexural strength, the pay factor for the lot will be between 1.0 and 1.06, as determined in accordance with Paragraph 501–8.1a. If the PWL is less than 80 percent, the pay factor for the lot will be less than 1.0, as determined in accordance with Paragraph 501–8.1a.

(2) **Thickness.** If the PWL of the lot equals or exceeds 90 percent for thickness, the pay factor for the lot will be 1.0, in accordance with Paragraph 501–8.1b. If the PWL is less than 90 percent, the factor for the lot will be less than 1.0, as determined in accordance with Paragraph 501–8.1b.

(3) **Smoothness.** When the concrete has hardened sufficiently, the pavement surface will be tested with a 16-foot (5 m) straightedge or other specified device. Surface smoothness deviations shall not exceed 1/4 inch (6 mm) from a 16-foot (5 m) straightedge placed in any direction, including placement along and spanning any pavement joint edge.

Areas in a slab showing high spots of more than 1/4 inch (6 mm) but not exceeding 1/2 inch (13 mm) in 16 feet (5 m) will be marked and immediately ground down with an approved grinding machine to an elevation that will fall within the tolerance of 1/4 inch (6 mm) or less. Where the departure from correct cross section exceeds 1/2 inch (13 mm), the pavement shall be removed and replaced at the expense of the Contractor when so directed by the Engineer.

(4) **Grade.** An evaluation of the surface grade will be made by the Engineer for compliance to the tolerances contained below.

Lateral Deviation. Lateral deviation from established alignment of the pavement edge shall not exceed plus or minus 0.10 foot (30 mm) in any lane.

Vertical Deviation. Vertical deviation from established grade shall not exceed plus or minus 0.04 foot (12 mm) at any point.

(5) **Edge Slump.** When slip-form paving is used, not more than 15 percent of the total free edge of each 500 feet (152 m) of pavement, or fraction thereof, shall have an edge slump exceeding 1/4-inch (6 mm), and none of the free edge of the pavement shall

have an edge slump exceeding 3/8-inch (10 mm). (The total free edge of 500 feet (152 m) of pavement will be considered the cumulative total linear measurement of pavement edge originally constructed as nonadjacent to any existing pavement; i.e., 500 feet (152 m) of paving lane originally constructed as a separate lane will have 1,000 feet (305 m) of free edge, 500 feet (152 m) of fill-in lane will have no free edge, etc.) The area affected by the downward movement of the concrete along the pavement edge shall be limited to not more than 18 inches (457 mm) from the edge. When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive edge slump shall be removed and replaced at the expense of the Contractor when so directed by the Engineer.

(6) Dowel Bar Alignment. Dowel bars and assemblies shall be checked for position and alignment. The maximum permissible tolerance on dowel bar alignment in each plane, horizontal and vertical, shall not exceed 2 percent or 1/4 inch (6 mm) per foot of dowel bar.

f. Removal and Replacement of Concrete. Any area or section of concrete that is removed and replaced shall be removed and replaced back to planned joints. Replace damaged dowels. The requirements for doweled longitudinal construction joints in Paragraph 501-4.10 shall apply to all contraction joints exposed by concrete removal.

CONTRACTOR QUALITY CONTROL

501-6.1 QUALITY CONTROL PROGRAM. Develop a Quality Control Program in accordance with Section 100 of the General Requirements and Covenants. Address all elements which affect the quality of the pavement including, but not limited to:

- a. Mix Design
- b. Aggregate Gradation
- c. Quality of Materials
- d. Stockpile Management
- e. Proportioning
- f. Mixing and Transportation
- g. Placing and Consolidation
- h. Joints
- i. Dowel Placement and Alignment
- j. Flexural or Compressive Strength
- k. Finishing and Curing
- l. Surface Smoothness
- m. Thickness

NOTE TO SPECIFIER:

When the area to be paved is less than 600 square yards (500 square meters), the Engineer may modify this requirement.

501-6.2 QUALITY CONTROL TESTING. Perform all quality control tests necessary to control the production and construction processes applicable to this Specification and as set forth in the Quality Control Program. Include in the testing program, but not necessarily limited to; tests for aggregate gradation, aggregate moisture content, slump, and air content.

Develop a Quality Control Testing Plan as part of the Quality Control Program.

a. Fine Aggregate.

(1) Gradation. Do a sieve analysis at least twice daily in accordance with ASTM C 136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) **Moisture Content.** If an electric moisture meter is used, do at least two direct measurements of moisture content per week to check the calibration. If direct measurements are made instead of using an electric meter, conduct two tests per day. Conduct tests in accordance with ASTM C 70 or ASTM C 566.

b. Coarse Aggregate.

(1) **Gradation.** Do a sieve analysis at least twice daily for each size of aggregate. Tests shall be made in accordance with ASTM C 136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) **Moisture Content.** If an electric moisture meter is used, do at least two direct measurements of moisture content per week to check the calibration. If direct measurements are made instead of using an electric meter, conduct two tests per day. Conduct tests in accordance with ASTM C 566.

c. Slump. Perform four slump tests for each lot of material produced in accordance with the lot size defined in Section 501–5.1. Conduct one test for each subplot. Perform Slump tests in accordance with ASTM C 143 from material randomly sampled from material discharged from trucks at the paving site. Take material samples in accordance with ASTM C 172.

d. Air Content. Perform four air content tests for each lot of material produced in accordance with the lot size defined in Section 501–5.1. Do one test for each subplot. Perform air content tests in accordance with ASTM C 231 for gravel and stone coarse aggregate and ASTM C 173 for slag or other porous coarse aggregate, from material randomly sampled from trucks at the plant site. Take material samples in accordance with ASTM C 172.

501–6.3 CONTROL CHARTS. Maintain linear control charts for fine and course aggregate, gradation, slump, and air content.

Post control charts in a location satisfactory to the Engineer and keep it up to date at all times. As a minimum, identify in the control charts the project number, the Contract Pay Item number, the test number, each test parameter, the Action and Suspension Limits, or Specification limits, applicable to each test parameter, and the Contractor's test results. Use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the projected data during production indicates a potential problem and the Contractor is not taking satisfactory corrective action, the Engineer may halt production or acceptance of the material.

a. Fine and Coarse Aggregate Gradation. Record the running average of the last five gradation tests for each control sieve on linear control charts. Specification limits contained in Tables 1 and 2 shall be superimposed on the Control Chart for job control.

b. Slump and Air Content. Maintain linear control charts both for individual measurements and range (i.e., difference between highest and lowest measurements per lot) for slump and air content in accordance with the following Action and Suspension Limits.

CONTROL CHART LIMITS

<i>Control Parameter</i>	<i>*Individual Measurements</i>	
	<i>Action Limit</i>	<i>Suspension Limit</i>
Slump	+/- 1 inch (25 mm)	+/- 1.5 inch (38 mm)
Air Content	+/- 1.2%	+/- 1.8%

* The individual measurement control charts shall use the Contractor's mix design values as indicators of central tendency

RANGE SUSPENSION LIMITS		
n (Number of samples)	Slump	Air
2	+/- 1.8 inch (45 mm)	+/- 2.2%
3	+/- 2.2 inch (55 mm)	+/- 2.6%
4	+/- 2.4 inch (6.0 mm)	+/- 2.8%
5	+/- 2.5 inch (62.5 mm)	+/- 3.0%
6	+/- 2.5 inch (62.5 mm)	+/- 3.0%

501-6.4 CORRECTIVE ACTION. Indicate in the Quality Control Plan the appropriate action to be taken when a process is believed to be out of control. Detail in the Plan what action will be taken to bring a process into control and have sets of rules to gauge when a process is out of control. As a minimum, a process shall be deemed out of control and corrective action taken if any one of the following conditions exists.

a. Fine and Coarse Aggregate Gradation. When two consecutive averages of five tests are outside of the Tables 1 or 2 specification limits, take immediate steps, including a halt to production, to correct the gradation.

b. Fine and Coarse Aggregate Moisture Content. Whenever the moisture content of the fine or coarse aggregate changes by more than 0.5 percent, adjust the scale settings for the aggregate batcher(s) and water batcher.

c. Slump. Halt production and make appropriate adjustments whenever:

- (1) One point falls outside the Suspension Limit line for individual measurements or range; or
- (2) Two points in a row fall outside the Action Limit line for individual measurements.

d. Air Content. Halt production and adjust the amount of air-entraining admixture whenever:

- (1) One point falls outside the Suspension Limit line for individual measurements or range; or
- (2) Two points in a row fall outside the Action Limit line for individual measurements.

Whenever a point falls outside the Action Limits line, calibrate the air-entraining admixture dispenser to ensure that it is operating correctly and with good reproducibility.

METHOD OF MEASUREMENT

501-7.1 Portland cement concrete pavement will be measured by the number of square yards of either plain or reinforced pavement as specified in-place, completed and accepted. Saw Cut Grooving will be measured by the number of square yards of Saw Cut Grooving as constructed in-place and accepted. Portland Cement Concrete Pavement Quality Management Program will be measured by the number of square yards of pavement constructed and accepted.

BASIS OF PAYMENT

501-8.1 GENERAL. Payment for an accepted lot of concrete pavement will be made at the Contract unit price per square yard adjusted in accordance with paragraphs 501-8.1a,b, and c. Payment will be full compensation for all labor, materials, tools, equipment, and incidentals required to complete the Work as specified herein and on the drawings, except for Saw Cut Grooving and Portland Cement Concrete Quality Management Program. Joint sealing filler shall be incidental and the cost included in the price for Portland Cement Concrete Pavement unless separate Pay Item is included in the Schedule of Prices.

a. Basis of Adjusted Payment for Flexural Strength (PFs). A pay factor for flexural strength will be determined in accordance with the following schedule when the percent within specification limits (PWL) equals or exceeds 60 percent.

Percent within Limits (PWL)	Pay Factor for Flexural Strength (PFs)
80-100	$0.76 + 0.003 \text{ PWL}$
60-79	$0.00017 \text{ PWL}^2 - 0.0105 \text{ PWL} + 0.75$

When the PWL is below 60 percent, the lot shall be removed and replaced. However, the Engineer may decide to accept the deficient lot. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it will be paid for at 50 percent of the Contract unit price.

NOTE TO SPECIFIER:
When the design strength in paragraph 501-3.1 is based on compressive strength, substitute compressive strength for flexural strength.

b. Basis of Adjusted Payment for Thickness (PFt). A pay factor for thickness will be determined in accordance with the following schedule when the percent within specification limits (PWL) equals or exceeds 25 percent.

**Percent within
Limits (PWL)**

Pay Factor for Thickness (PFt)

90–100	1.0
25–89	$0.000034 \times \text{PWL}^2 - 0.00006 \times \text{PWL} + 0.72$

Remove and replace the lot when the PWL is below 25 percent. However, the Engineer may decide to accept the deficient lot. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it will be paid for at 50 percent of the Contract unit price.

c. Lot Pay Factor. The percent payment for an accepted lot will be arrived at by successively multiplying the Contract unit price by both factors determined in paragraphs 501-8.1a and 501-8.1b.

$$\text{PFs} \times \text{PFt} \times \text{Contract unit price} = \text{Adjusted payment for lot}$$

501–8.2 PAYMENT FOR SAW CUT GROOVING. Payment for Saw Cut Grooving will be made at the Contract unit price per square yard and will be full compensation for all labor, materials, tools, equipment and incidentals required to complete the Work as specified.

501–8.3 Payment for Portland Cement Concrete Pavement Quality Management Program will be made at the Contract unit price per square yard and will be full compensation for all labor, materials, tools, equipment, and incidentals required to complete the Work as specified.

501–8.4 Standard Pay Items for Work covered by this Specification are as follows:

Pay Item P50101	Portland Cement Concrete Pavement, 6 inch, per square yard
Pay Item P50102	Portland Cement Concrete Pavement, 7 inch, per square yard
Pay Item P50103	Portland Cement Concrete Pavement, 8 inch, per square yard
Pay Item P50104	Portland Cement Concrete Pavement, 9 inch, per square yard
Pay Item P50105	Portland Cement Concrete Pavement, 10 inch, per square yard
Pay Item P50106	Portland Cement Concrete Pavement, 11 inch, per square yard
Pay Item P50107	Portland Cement Concrete Pavement, 12 inch, per square yard
Pay Item P50108	Portland Cement Concrete Pavement, 13 inch, per square yard
Pay Item P50109	Portland Cement Concrete Pavement, 14 inch, per square yard
Pay Item P50110	Portland Cement Concrete Pavement, 15 inch, per square yard
Pay Item P50111	Portland Cement Concrete Pavement, 16 inch, per square yard
Pay Item P50112	Portland Cement Concrete Pavement, 17 inch, per square yard
Pay Item P50113	Portland Cement Concrete Pavement, 18 inch, per square yard
Pay Item P50114	Portland Cement Concrete Pavement, 19 inch, per square yard
Pay Item P50115	Portland Cement Concrete Pavement, 20 inch, per square yard
Pay Item P50116	Portland Cement Concrete Pavement, 21 inch, per square yard
Pay Item P50117	Portland Cement Concrete Pavement, 22 inch, per square yard
Pay Item P50118	Portland Cement Concrete Pavement, 23 inch, per square yard
Pay Item P50119	Portland Cement Concrete Pavement, 24 inch, per square yard
Pay Item P50131	Portland Cement Concrete Pavement Quality Management Program, per square yard
Pay Item P50132	Saw Cut Grooving, per square yard

Measurement and Payment will only be made for Pay Items included in the Schedule of Prices. The cost of all Work required by the Contract Documents will be included in the Pay Items contained in the Schedule of Prices.

TESTING REQUIREMENTS

ASTM C 31	Making and Curing Concrete Test Specimens in the Field
ASTM C 39	Compressive Strength of Cylindrical Concrete Specimens
ASTM C 70	Surface Moisture in Fine Aggregate
ASTM C 78	Test for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C 131	Test for Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C 136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C 138	Test for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete
ASTM C 143	Test for Slump of Portland Cement Concrete
ASTM C 172	Sampling Freshly Mixed Concrete
ASTM C 173	Test for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 174	Measuring Length of Drilled Concrete Cores
ASTM C 227	Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
ASTM C 231	Test for Air Content of Freshly Mixed Concrete by the Pressure Method

ASTM C 289	Potential Reactivity of Aggregates (Chemical Method)
ASTM C 295	Petrographic Examination of Aggregates for Concrete
ASTM C 311	Sampling and Testing Fly Ash for Use as an Admixture in Portland Cement Concrete
ASTM C 535	Test for Resistance to Abrasion of Large Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C 566	Total Moisture Content of Aggregates by Drying
ASTM C 1077	Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM D 3665	Random Sampling of Construction Materials
ASTM D 4791	Test Method for Flat or Elongated Particles in Coarse Aggregate
AASHTO T 26	Quality of Water to be Used in Concrete

MATERIAL REQUIREMENTS

ASTM A 184	Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A 185	Specification for Welded Steel Wire Fabric for Concrete Reinforcement
ASTM A 497	Specification for Welded Deformed Steel Wire Fabric for Concrete Pavement
ASTM A 615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 616	Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 617	Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 704	Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
ASTM A 714	Specification for High-Strength Low-Alloy Welded and Seamless Steel Pipe
ASTM C 33	Specification for Concrete Aggregates
ASTM C 94	Specification for Ready-Mixed Concrete
ASTM C 150	Specification for Portland Cement
ASTM C 171	Specification for Sheet Materials for Curing Concrete
ASTM C 260	Specification for Air-Entraining Admixtures for Concrete
ASTM C 309	Specification for Liquid Membrane-Forming Compounds
ASTM C 494	Specification for Chemical Admixtures for Concrete
ASTM C 595	Specification for Blended Hydraulic Cements
ASTM C 618	Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 666	Test Method for Resistance of Concrete to Rapid Freezing and Thawing
ASTM C 881	Specification for Epoxy-Resin Base Bonding System for Concrete
ASTM C 989	Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM D 1751	Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
AASHTO M 254	Specification for Coated Dowel Bars
ACI 305R	Hot Weather Concreting
ACI 306R	Cold Weather Concreting
TT-P-644	Federal Specification for Primer Coating, Alkyd, (Rev. D) Corrosion-Inhibiting, Lead and Chromate Free, VOC-Compliant