

# **RIGID PAVEMENT ITEMS**

# ITEM P-501 CEMENT CONCRETE PAVEMENT

## DESCRIPTION

**501-1.1** This work shall consist of pavement composed of cement concrete with and without reinforcement 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. The terms cement concrete, hydraulic cement concrete, and concrete are interchangeable in this specification.

## MATERIALS

### 501-2.1 AGGREGATES.

- a. Reactivity.** Fine and Coarse aggregates to be used in PCC on this project shall be tested and evaluated by the Contractor for alkali-aggregate reactivity in accordance with both ASTM C1260 and ASTM C1567. Tests must be representative of aggregate sources which will be providing material for production. ASTM C1260 and ASTM C1567 tests may be run concurrently.
- (1)** Coarse aggregate and fine aggregate shall be tested separately in accordance with ASTM C1260, however, the length of test shall be extended to 28 days (30 days from casting). Tests must have been completed within 6 months of the date of the concrete mix submittal.
  - (2)** The combined coarse and fine aggregate shall be tested in accordance with ASTM C1567, modified for combined aggregates, using the proposed mixture design proportions of aggregates, cementitious materials, and/or specific reactivity reducing chemicals. If the expansion does not exceed 0.10% at 28 days, the proposed combined materials will be accepted. If the expansion is greater than 0.10% at 28 days, the aggregates will not be accepted unless adjustments to the combined materials mixture can reduce the expansion to less than 0.10% at 28 days, or new aggregates shall be evaluated and tested.
  - (3)** If lithium nitrate is proposed for use with or without supplementary cementitious materials, the aggregates shall be tested in accordance with Corps of Engineers (COE) Concrete Research Division (CRD) C662 in lieu of ASTM C1567. If lithium nitrate admixture is used, it shall be nominal 30%  $\pm$ 0.5% weight lithium nitrate in water. If the expansion does not exceed 0.10% at 28 days, the proposed combined materials will be accepted. If the expansion is greater than 0.10% at 28 days, the aggregates will not be accepted unless adjustments to the combined materials mixture can reduce the expansion to less than 0.10% at 28 days, or new aggregates shall be evaluated and tested.
- b. Fine aggregate.** Grading of the fine aggregate, as delivered to the mixer, shall conform to the requirements of ASTM C33 and the parameters identified in the fine aggregate material requirements below. Fine aggregate material requirements and deleterious limits are shown in Tables 501-1 and 501-2, below.

**TABLE 501-1  
FINE AGGREGATE MATERIAL REQUIREMENTS**

<b>MATERIAL TEST</b>	<b>REQUIREMENT</b>	<b>STANDARD</b>
Soundness of Aggregates by Use of Sodium Sulfate	Loss after 5 cycles: 10% maximum using Sodium sulfate	ASTM C88
Sand Equivalent	45 minimum	ASTM D2419
Fineness Modulus (FM)	$2.50 \leq FM \leq 3.40$	ASTM C136

**TABLE 501-2  
LIMITS FOR DELETERIOUS SUBSTANCES IN FINE AGGREGATE FOR CONCRETE**

<b>MATERIAL TEST</b>	<b>REQUIREMENT</b>	<b>STANDARD</b>
Clay lumps and friable particles	1.0% maximum	ASTM C142
Coal and lignite	0.5% max., using a medium with a density of Sp. Gr. of 2.0	ASTM C123
Total Deleterious Material	1.0% maximum	

**c. Coarse aggregate.** The maximum size coarse aggregate shall be 1-1/2-inch.

Aggregates delivered to the mixer shall be clean, hard, uncoated aggregates consisting of crushed stone, crushed or uncrushed gravel, air-cooled iron blast furnace slag, crushed recycled concrete pavement, or a combination. The aggregates shall have no known history of detrimental pavement staining. Steel blast furnace slag shall not be permitted. Coarse aggregate material requirements and deleterious limits are shown in Tables 501-3 and 501-4, below; washing may be required to meet aggregate requirements.

**TABLE 501-3  
COARSE AGGREGATE MATERIAL REQUIREMENTS**

<b>MATERIAL TEST</b>	<b>REQUIREMENT</b>	<b>STANDARD</b>
Resistance to Degradation	Loss: 40% maximum	ASTM C131
Soundness of Aggregates by Use of Sodium Sulfate	Loss after 5 cycles: 12% maximum using Sodium sulfate	ASTM C88
Flat, Elongated, or Flat and Elongated Particles	8% maximum, by weight, of flat, elongated, or flat and elongated particles at 5:1 for any size group coarser than 3/8 sieve <sup>1</sup>	ASTM D4791
Bulk density of slag <sup>2</sup>	Weigh not less than 70 pounds per cubic foot	ASTM C29

<sup>1</sup> A flat particle is one having a ratio of width to thickness greater than five (5); an elongated particle is one having a ratio of length to width greater than five (5).

<sup>2</sup> Only required if slag is specified.

The amount of deleterious material in the coarse aggregate shall not exceed the limits in Table 501-4:

**TABLE 501-4  
LIMITS FOR DELETERIOUS SUBSTANCES IN COARSE AGGREGATE**

<b>DELETERIOUS MATERIAL</b>	<b>STANDARD</b>	<b>PERCENTAGE BY MASS</b>
Clay Lumps and friable particles	ASTM C142	1.0
Material finer than No. 200 sieve	ASTM C117	1.0 <sup>1</sup>
Lightweight particles	ASTM C123 using a medium with a density of Sp. Gr. of 2.0	0.5
Chert <sup>2</sup> (less than 2.40 Sp Gr.)	ASTM C123 using a medium with a density of Sp. Gr. of 2.40)	0.1 <sup>3</sup>

<sup>1</sup> The limit for material finer than 75-µm is allowed to be increased to 1.5% for crushed aggregates consisting of dust of fracture that is essentially free from clay or shale. Test results supporting acceptance of increasing limit to 1.5% with statement indicating material is dust of fracture must be submitted with Concrete mix. Acceptable techniques to characterizing these fines include methylene blue adsorption or X-ray diffraction analysis.

<sup>2</sup> Chert and aggregates with less than 2.4 specific gravity.

<sup>3</sup> The limit for chert may be increased to 1.0 percent by mass in areas not subject to severe freeze and thaw.

**d. Combined aggregate gradation.** This specification is targeted for a combined aggregate gradation developed following the guidance presented in United States Air Force Engineering Technical Letter (ETL) 97-5: Proportioning Concrete Mixtures with Graded Aggregates for Rigid Airfield Pavements. Base the aggregate grading upon a combination of all the aggregates (coarse and fine) to be used for the mixture proportioning. Three aggregate sizes may be required to achieve an optimized combined gradation that will produce a workable concrete mixture for its intended use. Use aggregate gradations that produce concrete mixtures with well-graded or optimized aggregate combinations. The Contractor shall submit complete mixture information necessary to calculate the volumetric components of the mixture. The combined aggregate grading shall meet the following requirements:

(1) The materials selected and the proportions used shall be such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in Subsection 501-2.1d(4) below, the point thus determined shall fall within the parallelogram described therein.

(2) The CF shall be determined from the following equation:

$$CF = \frac{\text{(cumulative percent retained on the 3/8 in. sieve)}(100)}{\text{(cumulative percent retained on the No. 8 sieve)}}$$

(3) The WF is defined as the percent passing the No. 8 sieve based on the combined gradation. However, WF shall be adjusted, upwards only, by 2.5 percentage points for each 94 pounds of cementitious material per cubic meter yard greater than 564 pounds per cubic yard.

(4) A diagram shall be plotted using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram a parallelogram shall be plotted with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, the grading of each size of aggregate used and the proportions selected shall be changed as necessary. The point determined by the plotting of the CF and WF may be adjusted during production  $\pm 3$  WF and  $\pm 5$  CF. Adjustments to gradation may not take the point outside of the parallelogram.

**e. Contractors combined aggregate gradation.** The Contractor shall submit their combined aggregate gradation using the format shown in Table 501-5:

**TABLE 501-5  
CONTRACTOR'S COMBINED AGGREGATE GRADATION**

<b>SIEVE SIZE</b>	<b>CONTRACTOR'S CONCRETE MIX GRADATION (PERCENT PASSING BY WEIGHT)</b>
2 inch	*
1-1/2 inch	*
1 inch	*
3/4 inch	*
1/2 inch	*
3/8 inch	*
No. 4	*
No. 8	*

SIEVE SIZE	CONTRACTOR'S CONCRETE MIX GRADATION (PERCENT PASSING BY WEIGHT)
No. 16	*
No. 30	*
No. 50	*
No. 100	*

**501-2.2 CEMENT.** Cement shall conform to the requirements of ASTM C150 Type II, including the low-alkali requirement.

**501-2.3 CEMENTITIOUS MATERIALS.**

- a. **Fly ash.** Fly ash shall meet the requirements of ASTM C618, with the exception of loss of ignition, where the maximum shall be less than 6%. Fly ash shall have a Calcium Oxide (CaO) content of less than 15% and a total alkali content less than 3% per ASTM C311. The Contractor shall furnish the previous three most recent, consecutive ASTM C618 reports for each source of fly ash proposed in the concrete mix, and shall furnish each additional report as they become available during the project. The reports can be used for acceptance or the material may be tested independently by the Engineer.
- b. **Slag cement (ground granulated blast furnace (GGBF)).** Slag cement shall conform to ASTM C989, Grade 100 or Grade 120. Slag cement shall be used only at a rate between 25% and 55% of the total cementitious material by mass.
- c. **Raw or calcined natural pozzolan.** Natural pozzolan shall be raw or calcined and conform to ASTM C618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 6%. Class N pozzolan for use in mitigating Alkali-Silica Reactivity shall have a total available alkali content less than 3%.

**501-2.4 JOINT SEAL.** The joint seal for the joints in the concrete pavement shall meet the requirements of Item P-605 and shall be of the type specified on the Plans.

**501-2.5 ISOLATION JOINT FILLER.** Premolded joint filler for isolation joints shall conform to the requirements of ASTM D1751 or ASTM D1752 and shall be where shown on the Plans. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint, unless otherwise specified by the Engineer. When the use of more than one piece is required for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means satisfactory to the Engineer.

**501-2.6 STEEL REINFORCEMENT.** Reinforcing shall consist of deformed steel bars conforming to the requirements of ASTM A615, Grade 60. Welded wire fabric shall be furnished in flat sheets only.  
**501-2.7 DOWEL AND TIE BARS.** Dowel bars shall be plain steel bars conforming to ASTM A615 and shall be free from burring or other deformation restricting slippage in the concrete.

- a. **Dowel Bars.** Before delivery to the construction site each dowel bar shall be epoxy coated per ASTM A1078, Type 1, with a coating thickness after curing greater than 10 mils. Patched ends are not required for Type 1 coated dowels. The dowels shall be coated with a bond-breaker recommended by the manufacturer. Dowel sleeves or inserts are not permitted. Grout retention rings shall be fully circular metal or plastic devices capable of supporting the dowel until the grout hardens.

- b. **Tie Bars.** Tie bars shall be deformed steel bars and conform to the requirements of ASTM A615. Tie bars designated as Grade 60 in ASTM A615 or ASTM A706 shall be used for construction requiring bent bars.

**501-2.8 WATER.** Water used in mixing or curing shall be potable. If water is taken from other sources considered non-potable, it shall meet the requirements of ASTM C1602.

**501-2.9 MATERIAL FOR CURING CONCRETE.** 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 C309, Type 2, Class A, or Class B.
- b. White polyethylene film for curing concrete shall conform to the requirements of ASTM C171.
- c. White burlap-polyethylene sheeting for curing concrete shall conform to the requirements of ASTM C171.
- d. Waterproof paper for curing concrete shall conform to the requirements of ASTM C171.

**501-2.10 ADMIXTURES.** Admixtures shall conform to the following specifications:

- a. **Air-entraining admixtures.** Air-entraining admixtures shall meet the requirements of ASTM C260 and shall consistently entrain the air content in the specified ranges under field conditions. The air-entraining agent and any water reducer admixture shall be compatible.
- b. **Water-reducing admixtures.** Water-reducing admixture shall meet the requirements of ASTM C494, Type A, B, or D.
- c. **Other admixtures.** The use of set retarding and set-accelerating admixtures shall be approved by the Engineer prior to developing the concrete mix design. Retarding admixtures shall meet the requirements of ASTM C494, Type A, B, or D and set-accelerating admixtures shall meet the requirements of ASTM C494, Type C. Calcium chloride and admixtures containing calcium chloride shall not be used.
- d. **Lithium Nitrate.** The lithium admixture shall be a nominal 30% aqueous solution of Lithium Nitrate, with a density of 10 pounds/gallon, and shall have the approximate chemical form as shown in Table 501-6, below:

**TABLE 501-6  
LITHIUM ADMIXTURE**

CONSTITUENT	LIMIT (PERCENT BY MASS)
LiNO <sub>3</sub> (Lithium Nitrate)	30 ±0.5
SO <sub>4</sub> (Sulfate Ion)	0.1 (max)
Cl (Chloride Ion)	0.2 (max)
Na (Sodium Ion)	0.1 (max)
K (Potassium Ion)	0.1 (max)

The lithium nitrate admixture dispensing and mixing operations shall be verified and certified by the lithium manufacturer's representative.

**501-2.11 EPOXY-RESIN.** All epoxy-resin materials shall be two-component materials conforming to the requirements of ASTM C881, Class as appropriate for each application temperature to be encountered, except that in addition, the materials shall meet the following requirements:

- a. Material for use for embedding dowels and anchor bolts shall be Type IV, Grade 3.
- b. Material for use as patching materials for complete filling of spalls and other voids and for use in preparing epoxy resin mortar shall be Type III, Grade as approved.
- c. Material for use for injecting cracks shall be Type IV, Grade 1.
- d. Material for bonding freshly mixed Portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete shall be Type V, Grade as approved.

**501-2.12 BOND BREAKER.** Not required.

**501-2.13 SURFACE SEALER.** Provide a liquid applied, water soluble hydrophobic pore lining impregnate that is specifically formulated to protect concrete from the detrimental effects of moisture intrusion, freeze-thaw cycles, chloride ion penetration, and deicing chemicals. Provide Pavix CCC100 manufactured by Chem-Crete, Hydrozo Enviroseal 40 by Chemrex, or an equal product containing 40 percent silane meeting AASHTO T 259, ASTM C 642, and ASTM C 672.

**501-2.14 ELASTOMERIC CONCRETE.** Elastomeric concrete shall consist of two component polyurethane product mix, sand aggregate, fiber, and priming compound per the manufacturer's recommendations. Material shall be Delpatch as manufactured by D.S. Brown Company, or pre-approved equal. Product shall have a minimum tensile strength of 600 psi, and a minimum shore D hardness of 50 per ASTM D2240. Elastomeric concrete shall be used when the concrete surface temperature is 45°F or above and ambient air temperature is 45°F and rising.

### **CONCRETE MIX**

**501-3.1. GENERAL.** No concrete shall be placed until an acceptable concrete mix design has been submitted to the Engineer for review and the Engineer has approved the concrete mix design in writing. The Engineer's review shall not relieve the Contractor of the responsibility to select and proportion the materials to comply with this section.

**501-3.2 CONCRETE MIX LABORATORY.** The laboratory used to develop the concrete design mix shall be accredited in accordance with ASTM C1077. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for developing the concrete mix design must be included in the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

**501-3.3 CONCRETE MIX PROPORTIONS.** Develop the mix using the procedures contained in Portland Cement Association (PCA) publication, "Design and Control of Concrete Mixtures". Concrete shall be proportioned to achieve a 28-day flexural strength that meets or exceeds the acceptance criteria contained in Subsection 501-6.6 for a flexural strength of 650 psi per ASTM C78.

The minimum cementitious material shall be adequate to ensure a workable, durable mix. The minimum cementitious material (cement plus fly ash, or slag cement) shall be 470 pounds per cubic yard. The ratio of water to cementitious material, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates shall be between 0.38 – 0.45 by weight.

Flexural strength test specimens shall be prepared in accordance with ASTM C192 and tested in accordance with ASTM C78. At the start of the project, the Contractor shall determine an allowable slump as determined by ASTM C143 not to exceed 2 inches for slip-form placement. For fixed-form placement, the slump shall not exceed 3 inches. For hand placement, the slump shall not exceed 4 inches.

The results of the concrete mix design shall include a statement giving the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic yard (meter) basis. Aggregate quantities shall be based on the mass in a saturated surface dry condition.

If a change in source(s) is made, or admixtures added or deleted from the mix, a new concrete mix design must be submitted to the Engineer for approval.

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

**501-3.4 CONCRETE MIX SUBMITTAL.** The concrete mix design shall be submitted to the Engineer at least 45 days prior to the start of operations. The submitted concrete mix design shall not be more than 180 days old and must use the materials to be used for production for the project. Production shall not begin until the concrete mix design is approved in writing by the Engineer.

Each of the submitted concrete mixes (i.e, slip form, side form machine finish and side form hand finish) shall be stamped or sealed by the responsible professional Engineer of the laboratory and shall include the following items and quantities as a minimum:

- a. Certified material test reports for aggregate in accordance with Subsection 501-2.1. Certified reports must include all tests required; reporting each test, test method, test result, and requirement specified (criteria).
- b. Combined aggregate gradations and analysis; and including plots of the fine aggregate fineness modulus.
- c. Reactivity Test Results.
- d. Coarse aggregate quality test results, including deleterious materials.
- e. Fine aggregate quality test results, including deleterious materials.
- f. Mill certificates for cement and supplemental cementitious materials.
- g. Certified test results for all admixtures, including Lithium Nitrate if applicable.
- h. Specified flexural strength, slump, and air content.
- i. Recommended proportions/volumes for proposed mixture and trial water-cementitious materials ratio, including actual slump and air content.
- j. Flexural and compressive strength summaries and plots, including all individual beam and cylinder breaks.
- k. Correlation ratios for acceptance testing and Contractor QC testing, when applicable.
- l. Historical record of test results documenting production standard deviation, when applicable.

**501-3.5 CEMENTITIOUS MATERIALS.**

- a. **Fly ash.** When fly ash is used as a partial replacement for cement, the replacement rate shall be determined from laboratory trial mixes, and shall be between 20 and 30% by weight of the total cementitious material. If fly ash is used in conjunction with slag cement the maximum replacement rate shall not exceed 10% by weight of total cementitious material.
- b. **Slag cement (ground granulated blast furnace (GGBF)).** Slag cement may be used. The slag cement, or slag cement plus fly ash if both are used, may constitute between 25 to 55% of the total cementitious material by weight.
- c. **Raw or calcined natural pozzolan.** Natural pozzolan may be used in the concrete mix design. When pozzolan is used as a partial replacement for cement, the replacement rate shall be determined from laboratory trial mixes, and shall be between 20 and 30% by weight of the total cementitious material. If pozzolan is used in conjunction with slag cement the maximum replacement rate shall not exceed 10% by weight of total cementitious material.

**501-3.6 ADMIXTURES.**

- a. **Air-entraining admixtures.** Air-entraining admixtures are to be added in such a manner that will ensure uniform distribution of the agent throughout the batch. The air content of freshly mixed air-entrained concrete shall be based upon 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 shall be 5.5%. Air content shall be determined by testing in accordance with ASTM C231



for gravel and stone coarse aggregate and ASTM C173 for slag and other highly porous coarse aggregate.

- b. Water-reducing admixtures.** Water-reducing admixtures shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Tests shall be conducted with the materials to be used in the work, in accordance with ASTM C494.
- c. Other admixtures.** Set controlling, and other approved admixtures shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Tests shall be conducted with the materials to be used in the work, in accordance with ASTM C494.
- d. Lithium nitrate.** Lithium nitrate shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements in accordance with Subsection 501-2.10d.

**501-3.7 PRE-PAVING MEETING.** A pre-paving meeting will be conducted after approval of the mix design. This meeting will be attended by the Contractor, material suppliers, subcontractors associated with the concrete, the Engineer and the testing laboratory. The mix design, paving plan, procedures for construction, curing process to be used, calibration and inspection of equipment, testing and inspection during full production paving will be discussed. The chain of command for both the Contractor and the State will be outlined. Contingency scenarios will also be discussed.

**501-3.8 PAVING PLAN.** Prior to the pre-paving meeting the Contractor shall submit a paving plan that includes all paving operations to the Engineer. The plan shall detail the paving operations including, material delivery, forming methods, anticipated material quantities to be placed per pour and list of project submittals that must be completed before paving.

## **CONSTRUCTION METHODS**

**501-4.1 CONTROL STRIP.** The control strip(s) shall be to the next planned joint after the initial 250 feet (75 m) of each type of pavement construction (slip-form pilot lane, slip-form fill-in lane, or fixed form). The Contractor shall demonstrate, in the presence of the Engineer, that the materials, concrete mix design, equipment, construction processes, and quality control processes meet the requirements of the Specifications. The concrete mixture shall be extruded from the paver meeting the edge slump tolerance and with little or no finishing. Pilot, fill-in, and fixed-form control strips will be accepted separately. Minor adjustments to the mix design may be required to place an acceptable control strip. The production mix will be the adjusted mix design used to place the acceptable control strip. Upon acceptance of the control strip by the Engineer, the Contractor must use the same equipment, materials, and construction methods for the remainder of concrete paving. Any adjustments to processes or materials must be approved in advance by the Engineer. The acceptable control strip shall be paid for in accordance with Subsection 501-6.6.

**501-4.2 EQUIPMENT.** The Contractor is responsible for the proper operation and maintenance of all equipment necessary for handling materials and performing all parts of the work to meet this specification.

- a. Plant and equipment.** The plant and mixing equipment shall conform to the requirements of ASTM C94 and/or ASTM C685. Each truck 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. The truck mixers shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades. The pickup and throwover blades shall be replaced when they have worn down 3/4 inch 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.

Equipment for transferring and spreading concrete from the transporting equipment to the paving lane in front of the finishing equipment shall be provided. The equipment shall be specially manufactured, self-propelled transfer equipment which will accept the concrete outside the paving lane and will spread it evenly across the paving lane in front of the paver and strike off the surface evenly to a depth which permits the paver to operate efficiently.

**b. Finishing equipment.**

(1) **Slip-form.** The standard method of constructing concrete pavements shall be with an approved slip-form paving equipment designed and operated to spread, consolidate, screed, and finish the freshly placed concrete in one complete pass of the machine so that the end result is a dense and homogeneous pavement which is achieved with a minimum of hand finishing. The paver-finisher shall be a heavy duty, self-propelled machine designed specifically for paving and finishing high quality concrete pavements.

(2) **Fixed-form.** On projects requiring less than 500 square yards of concrete pavement or irregular areas at locations inaccessible to slip-form paving equipment, concrete pavement may be placed with equipment specifically designed for placement and finishing using stationary side forms. Methods and equipment shall be reviewed and accepted by the Engineer. Hand screeding and float finishing may only be used on small irregular areas as allowed by the Engineer.

**c. Vibrators.** Vibrator shall be the internal type. The rate of vibration of each vibrating unit shall be sufficient to consolidate the pavement without segregation or voids. The number, spacing, and frequency shall be as necessary to provide a dense and homogeneous pavement and meet the recommendations of American Concrete Institute (ACI) 309R, Guide for Consolidation of Concrete. Adequate power to operate all vibrators shall be available on the paver. The vibrators shall be automatically controlled so that they shall be stopped as forward motion ceases. The Contractor shall provide an electronic or mechanical means to monitor vibrator status. The checks on vibrator status shall occur a minimum of two times per day or when requested by the Engineer.

Hand held vibrators may only be used in irregular areas and shall meet the recommendations of ACI 309R, Guide for Consolidation of Concrete.

**d. Concrete saws.** The Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions. The Contractor shall 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.

**e. Fixed forms.** Straight side fixed forms shall be made of steel and shall be furnished in sections not less than 10 feet in length. Forms shall be provided 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. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built-up forms shall not be used, except as approved by the Engineer. The top face of the form shall not vary from a true plane more than 1/8 inch in 10 feet, and the upstanding leg shall not vary more than 1/4 inch. 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. The forms shall extend the full depth of the pavement section.

**501-4.3 FORM SETTING.** Forms shall be set to line and grade as shown on the Plans, sufficiently in advance of the concrete placement, to ensure continuous paving operation. Forms shall be set to withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the concrete placement.

**501-4.4 BASE SURFACE PREPARATION PRIOR TO PLACEMENT.** Any damage to the prepared base, subbase, and subgrade shall be corrected full depth by the Contractor prior to concrete placement. The underlying surface shall be entirely free of frost when concrete is placed. The prepared grade shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete.

**501-4.5 HANDLING, MEASURING, AND BATCHING MATERIAL.** Aggregate stockpiles shall be constructed and managed in such a manner that prevents segregation and intermixing of deleterious materials. Aggregates from different sources shall be stockpiled, weighed and batched separately at the concrete batch plant. Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Store and maintain all aggregates at a uniform moisture content prior to use. A continuous supply of materials shall be provided to the work to ensure continuous placement.

**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. Mixing time shall be measured from the time all materials are placed into the drum until the drum is emptied into the truck. All concrete shall be mixed and delivered to the site in accordance with the requirements of ASTM C94 or ASTM C685.

Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators, or non-agitating trucks. The elapsed time from the addition of cementitious material to the mix until the concrete is discharged from the truck should not exceed 30 minutes when the concrete is hauled in non-agitating trucks, nor 90 minutes when the concrete is hauled in truck mixers or truck agitators. In no case shall the temperature of the concrete when placed exceed 90°F. Retempering concrete by adding water or by other means will not be permitted. 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 is not exceeded.

**501-4.7 WEATHER LIMITATIONS ON MIXING AND PLACING.** No concrete shall be mixed, placed, or finished 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, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 40°F and shall not be resumed until an ascending air temperature in the shade and away from artificial heat reaches 35°F.

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 at the time of placement. Concrete shall not be placed on frozen material nor shall frozen aggregates be used in the concrete.

When concreting is authorized during cold weather, water and/or the aggregates may be heated to not more than 150°F. The apparatus used shall heat the mass uniformly and shall be arranged to preclude the possible occurrence of overheated areas which might be detrimental to the materials.

Curing during cold weather shall be in accordance with Subsection 501-4.13d.

- b. **Hot weather.** During periods of hot weather when the maximum daily air temperature exceeds 85°F, the following precautions shall be taken.

The forms and/or the underlying surface shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 90°F. The aggregates and/or mixing

water shall be cooled as necessary to maintain the concrete temperature at or not more than the specified maximum.

The concrete placement shall be protected from exceeding an evaporation rate of 0.2 psf per hour. When conditions are such that problems with plastic cracking can be expected, and particularly if any plastic cracking begins to occur, the Contractor shall immediately take such additional measures as necessary to protect the concrete surface. If the Contractor's measures are not effective in preventing plastic cracking, paving operations shall be immediately stopped.

Curing during hot weather shall be in accordance with Subsection 501-4.13e.

- c. Temperature management program.** Prior to the start of paving operation for each day of paving, the Contractor shall provide the Engineer with a Temperature Management Program for the concrete to be placed to assure that uncontrolled cracking is avoided. (Federal Highway Administration HIPERPAV 3 is one example of a temperature management program.) As a minimum, the program shall address the following items:

- (1) Anticipated tensile strains in the fresh concrete as related to heating and cooling of the concrete material.
- (2) Anticipated weather conditions such as ambient temperatures, wind velocity, and relative humidity; and anticipated evaporation rate using Figure 19-9, PCA, Design and Control of Concrete Mixtures.
- (3) Anticipated timing of initial sawing of joint.
- (4) Anticipated number and type of saws to be used.

- d. Rain.** The Contractor shall have available materials for the protection of the concrete during inclement weather. Such protective materials shall consist of rolled polyethylene sheeting at least 4 mils 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, all paving operations shall stop and all available personnel shall begin covering the surface of the unhardened concrete with the protective covering.

**501-4.8 CONCRETE PLACEMENT.** At any point in concrete conveyance, the free vertical drop of the concrete from one point to another or to the underlying surface shall not exceed 3 feet. The finished concrete product must be dense and homogeneous, without segregation and conforming to the standards in this specification. Backhoes and grading equipment shall not be used to distribute the concrete in front of the paver. Front end loaders will not be used. All concrete shall be consolidated without voids or segregation, including under and around all load-transfer devices, joint assembly units, and other features embedded in the pavement. 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 or a compressive strength of 3,100 psi, based on the average of four field cured specimens per 2,000 cubic yards of concrete placed. The Contractor must determine that the above minimum strengths are adequate to protection the pavement from overloads due to the construction equipment proposed for the project.

The Contractor shall have available materials for the protection of the concrete during cold, hot and/or inclement weather in accordance with Subsection 501-4.7.

- a. Slip-form construction.** The concrete shall be distributed uniformly into final position by a self-propelled slip-form paver without delay. The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose. The paver shall vibrate the concrete for the full width and depth of the strip of pavement being placed and the vibration shall be adequate to provide a consistency of concrete that will stand normal to the surface with sharp

well-defined edges. The sliding forms shall be rigidly held together laterally to prevent spreading of the forms. The plastic concrete shall be effectively consolidated by internal vibration with transverse vibrating units for the full width of the pavement and/or a series of equally placed longitudinal vibrating units. The space from the outer edge of the pavement to longitudinal unit shall not exceed 9 inches for slipform and at the end of the dowels for the fill-in lanes. The spacing of internal units shall be uniform and shall not exceed 18 inches.

The term internal vibration means vibrating units located within the specified thickness of pavement section.

The rate of vibration of each vibrating unit shall be sufficient to consolidate the pavement without, segregation, voids, or vibrator trails and the amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete along the entire length of the vibrating unit and for a distance of at least one foot. The frequency of vibration or amplitude should be adjusted proportionately with the rate of travel to result in a uniform density and air content. The paving machine shall be equipped with a tachometer or other suitable device for measuring and indicating the actual frequency of vibrations.

The concrete shall be held at a uniform consistency. The slip-form paver shall be operated with as nearly a continuous forward movement as possible and all operations of mixing, delivering, and spreading concrete shall be coordinated to provide uniform progress with stopping and starting of the paver held to a minimum. If for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

When concrete is being placed adjacent to an existing pavement, that part of the equipment which is supported on the existing pavement shall be equipped with protective pads on crawler tracks or rubber-tired wheels on which the bearing surface is offset to run a sufficient distance from the edge of the pavement to avoid breaking the pavement edge.

Not more than 15% of the total free edge of each 500-foot segment of pavement, or fraction thereof, shall have an edge slump exceeding 1/4 inch, and none of the free edge of the pavement shall have an edge slump exceeding 3/8 inch. (The total free edge of 500 feet of pavement will be considered the cumulative total linear measurement of pavement edge originally constructed as nonadjacent to any existing pavement; that is, 500 feet of paving lane originally constructed as a separate lane will have 1,000 feet of free edge, 500 feet 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 from the edge.

When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive edge slump will be removed the full width of the slip form lane and replaced at the expense of the Contractor as directed by the Engineer.

- b. Fixed-form construction.** Forms shall be drilled in advance of being placed to line and grade to accommodate tie bars / dowel bars where these are specified.

Immediately in advance of placing concrete and after all subbase operations are completed, side forms shall be trued and maintained to the required line and grade for a distance sufficient to prevent delay in placing.

Side forms shall remain in place at least 12 hours after the concrete has been placed, and in all cases until the edge of the pavement no longer requires the protection of the forms. Curing compound shall be applied to the concrete immediately after the forms have been removed.

Side forms shall be thoroughly cleaned and coated with a release agent each time they are used and before concrete is placed against them.

Concrete shall be spread, screed, shaped and consolidated by one or more self-propelled machines. These machines shall uniformly distribute and consolidate concrete without segregation so that the completed pavement will conform to the required cross-section with a minimum of handwork.

The number and capacity of machines furnished shall be adequate to perform the work required at a rate equal to that of concrete delivery. The equipment must be specifically designed for placement and finishing using stationary side forms. Methods and equipment shall be reviewed and accepted by the Engineer.

Concrete for the full paving width shall be effectively consolidated by internal vibrators. The rate of vibration of each vibrating unit shall be sufficient to consolidate the pavement without segregation, voids, or leaving vibrator trails.

Power to vibrators shall be connected so that vibration ceases when forward or backward motion of the machine is stopped.

- c. **Consolidation.** Concrete shall be consolidated with the specified type of lane-spanning, gang-mounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand-operated vibrators. The vibrators shall be inserted into the concrete to a depth that will provide the best full-depth consolidation but not closer to the underlying material than 2 inches. Vibrators shall not be used to transport or spread the concrete. For each paving train, at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators shall be maintained at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) or over-consolidation (vibrator trails, segregation, or any other evidence) shall require the immediate stopping of the paving operation and adjustment of the equipment or procedures as approved by the Engineer.

If a lack of consolidation of the hardened concrete is suspected by the Engineer, referee testing may be required. Referee testing of hardened concrete will be performed by the Engineer by cutting cores from the finished pavement after a minimum of 24 hours curing. The Engineer shall visually examine the cores for evidence of lack of consolidation. Density determinations will be made by the Engineer based on the water content of the core as taken. ASTM C642 shall be used for the determination of core density in the saturated-surface dry condition. When required, referee cores will be taken at the minimum rate of one for each 500 cubic yards of pavement, or fraction. The Contractor shall be responsible for all referee testing cost if cores fail to meet the required density.

The average density of the cores shall be at least 97% of the original concrete mix density, with no cores having a density of less than 96% of the original concrete mix density. Failure to meet the referee tests will be considered evidence that the minimum requirements for vibration are inadequate for the job conditions. Additional vibrating units or other means of increasing the effect of vibration shall be employed so that the density of the hardened concrete conforms to the above requirements.

**501-4.9 STRIKE-OFF OF CONCRETE AND PLACEMENT OF REINFORCEMENT.** Following the placing of the concrete, it shall be struck off to conform to the cross-section shown on the Plans and to an elevation 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, the bottom layer shall be struck off to such 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. The reinforcement shall then be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck off, and screed. If any portion of the bottom layer of concrete has been placed more than 30 minutes without being covered with the top layer or if initial set has taken place, it shall be removed and replaced with freshly mixed concrete at the Contractor's expense. 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.** Joints shall be constructed as shown on the Plans and in accordance with these requirements. All joints shall be constructed with their faces perpendicular to the surface of the pavement and finished or edged as shown on the Plans. Joints shall not vary more than 1/2-inch from their designated position and shall be true to line with not more than 1/4-inch variation in 10 feet. The surface across the joints shall be tested with a 12-foot straightedge as the joints are finished and any irregularities in excess of 1/4 inch shall be corrected before the concrete has hardened. All joints shall be so prepared, finished, or cut to provide a groove of uniform width and depth as shown on the Plans.

- a. **Construction.** Longitudinal construction joints shall be slip-formed or formed against side forms as shown in the Plans.

Transverse construction joints shall be installed at the end of each day's placing operations and at any 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. The installation of the joint shall be located at a planned contraction or expansion joint. If placing of the concrete is stopped, the Contractor shall remove the excess concrete back to the previous planned joint.

- b. **Contraction.** Contraction joints shall be installed at the locations and spacing as shown on the Plans. Contraction joints shall be installed 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 the sides of the grooves shall be finished 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. The groove shall be finished or cut clean so that spalling will be avoided at intersections with other joints. Grooving or sawing shall produce a slot at least 1/8 inch wide and to the depth shown on the Plans.

- c. **Isolation (expansion).** Isolation joints shall be installed as shown on the Plans. The premolded filler of the thickness as shown on the Plans, shall extend for the full depth and width of the slab at the joint. The filler shall be fastened uniformly along the hardened joint face with no buckling or debris between the filler and the concrete interface, including a temporary filler for the sealant reservoir at the top of the slab. The edges of the joint shall be finished and tooled while the concrete is still plastic

- d. **Dowels and Tie Bars for Joints**

- (1) **Tie bars.** Tie bars shall consist of deformed bars installed in joints as shown on the Plans. Tie bars shall be placed at right angles to the centerline of the concrete slab and shall be spaced at intervals shown on the Plans. They shall be held in position parallel to the pavement surface and in the middle of the slab depth and within the tolerances in Subsection 501-4.10d (3). 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. Tie bars shall not be painted, greased, or enclosed in sleeves. When slip-form operations call for tie bars, two-piece hook bolts can be installed.

- (2) **Dowel bars.** Dowel bars shall be placed across joints in the proper horizontal and vertical alignment as shown on the Plans. The dowels shall be coated with a bond-breaker or other

lubricant recommended by the manufacturer and approved by the Engineer. Dowels bars at longitudinal construction joints shall be bonded in drilled holes.

- (3) Placing dowels and tie bars.** Horizontal spacing of dowels shall be within a tolerance of  $\pm 3/4$  inch. The vertical location on the face of the slab shall be within a tolerance of  $\pm 1/2$ -inch. The method used to install dowels shall ensure that the horizontal and vertical alignment will not be greater than 1/4-inch per feet, except for those across the crown or other grade change joints. Dowels across crowns and other joints at grade changes shall be measured to a level surface. Horizontal alignment shall be checked perpendicular to the joint edge. The portion of each dowel intended to move within the concrete or expansion cap shall be wiped clean and coated with a thin, even film of lubricating oil or light grease before the concrete is placed. Dowels shall be installed as specified in the following Subsections.

Dowels and tie bars shall not be placed closer than 0.6 times the dowel bar or tie bar length to the planned joint line. If the last regularly spaced longitudinal dowel and/or tie bar is closer than that dimension, it shall be moved away from the joint to a location 0.6 times the dowel bar and/or tie bar length, but not closer than 6 inches to its nearest neighbor.

- (a) Contraction joints.** Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane shall be held securely in place by means of rigid metal frames or basket assemblies of an approved type. The basket assemblies shall be held securely in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires.

At the Contractor's option, dowels and tie bars in contraction joints may be installed by insertion into the plastic concrete using approved equipment and procedures per the paver manufacturer's design. Approval of installation methods will be based on the results of the control strip showing that the dowels and tie bars are installed within specified tolerances as verified by cores or non-destructive rebar location devices approved by the Engineer.

- (b) Construction joints.** Install dowels and tie bars by the cast-in- place or the drill-and-dowel method. Installation by removing and replacing in preformed holes will not be permitted. Dowels and tie bars shall be prepared and placed across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms.

- (c) Joints in hardened concrete.** Install dowels in hardened concrete by bonding the dowels into holes drilled into the concrete. The concrete shall have cured for seven (7) days or reached a minimum compressive strength of 3100 psi or flexural strength of 450 psi before drilling begins. Holes 1/8 inch greater in diameter than the dowels shall be drilled into the hardened concrete using rotary-core drills. Rotary-percussion drills may be used, provided that excessive spalling does not occur. Spalling beyond the limits of the grout retention ring will require modification of the equipment and operation. Depth of dowel hole shall be within a tolerance of  $\pm 1/2$ -inch of the dimension shown on the drawings. On completion of the drilling operation, the dowel hole shall be blown out with oil-free, compressed air. Dowels shall be bonded in the drilled holes using epoxy resin. Epoxy resin shall be injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel will not be permitted. The dowels shall be held in alignment at the collar of the hole by means of a suitable metal or plastic grout retention ring fitted around the dowel.

- e. Sawing of joints.** Sawing shall commence, without regard to day or night, 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 and shall continue without



interruption until all joints have been sawn. All slurry and debris produced in the sawing of joints shall be removed from the joints and adjacent areas by vacuuming and washing or flushing with a jet of water. Curing compound or system shall be reapplied after each saw-cut and maintained for the remaining cure period.

Joints shall be cut in locations as shown on the Plans. The initial joint cut shall be a minimum 1/8 inch wide and to the depth shown on the Plans. Prior to placement of joint sealant or seals, the top of the joint shall be widened by sawing as shown on the Plans.

Temporary backer rod shall be inserted into the joint following the initial sawcut. The backer rod shall be one size larger than the initial sawcut and no more than 1/4-inch below the top surface of the slab. Temporary backer rods shall be maintained in place until the second sawcut in preparation for joint sealing. Temporary backer material shall not be reused as part of the joint sealing operation.

**501-4.11 FINISHING.** Finishing operations shall be a continuing part of placing operations starting immediately behind the strike-off of the paver. Initial finishing shall be provided by the transverse screed or extrusion plate. The sequence of operations shall be transverse finishing, longitudinal machine floating if used, straightedge finishing, edging of joints, and then texturing. Finishing shall be by the machine method. The hand method shall be used only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Supplemental hand finishing for machine finished pavement shall be kept to an absolute minimum. Any machine finishing operation which requires appreciable hand finishing, other than a moderate amount of straightedge finishing, shall be immediately stopped and proper adjustments made or the equipment replaced. Equipment, mixture, and/or procedures which produce more than 1/4-inch of mortar-rich surface shall be immediately modified as necessary to eliminate this condition or operations shall cease. Compensation shall be made for surging behind the screeds or extrusion plate and settlement during hardening and care shall be taken to ensure that paving and finishing machines are properly adjusted so that the finished surface of the concrete (not just the cutting edges of the screeds) will be at the required line and grade. Finishing equipment and tools shall be maintained clean and in an approved condition. At no time shall water be added to the surface of the slab with the finishing equipment or tools, or in any other way. Fog (mist) sprays or other surface applied finishing aids specified to prevent plastic shrinkage cracking, approved by the Engineer, may be used in accordance with the manufacturers requirements.

- a. **Machine finishing with slipform pavers.** The slipform paver shall be operated so that only a very minimum of additional finishing work is required to produce pavement surfaces and edges meeting the specified tolerances. Any equipment or procedure that fails to meet these specified requirements shall immediately be replaced or modified as necessary. A self-propelled non-rotating pipe float may be used while the concrete is still plastic, to remove minor irregularities and score marks. Only one pass of the pipe float shall be allowed. Equipment, mixture, and/or procedures which produce more than 1/4-inch of mortar-rich surface shall be immediately modified as necessary to eliminate this condition or operations shall cease. Remove excessive slurry from the surface with a cutting straightedge and wipe off the edge. Any slurry which does run down the vertical edges shall be immediately removed by hand, using stiff brushes or scrapers. No slurry, concrete or concrete mortar shall be used to build up along the edges of the pavement to compensate for excessive edge slump, either while the concrete is plastic or after it hardens.
- b. **Machine finishing with fixed forms.** The machine shall be designed to straddle the forms and shall be operated to screed and consolidate the concrete. Machines that cause displacement of the forms shall be replaced. The machine shall make only one pass over each area of pavement. If the equipment and procedures do not produce a surface of uniform texture, true to grade, in one pass, the operation shall be immediately stopped and the equipment, mixture, and procedures adjusted as necessary.

- c. **Other types of finishing equipment.** Clary screeds, other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd-shaped slabs, and near buildings or trench drains, subject to the Engineer's approval.

Bridge deck finishers shall have a minimum operating weight of 7500 pounds and shall have a transversely operating carriage containing a knock-down auger and a minimum of two immersion vibrators. Vibrating screeds or pans shall be used only for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

- d. **Hand finishing.** Hand finishing methods will not be 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 and (2) in areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical.

- e. **Straightedge testing and surface correction.** After the pavement has been struck off and while the concrete is still plastic, it shall be tested for trueness with a 12-foot finishing straightedge swung from handles capable of spanning at least one-half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the centerline and the whole area gone over 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. Any excess water and laitance in excess of 1/8 inch thick shall be removed from the surface of the pavement and wasted. Any depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the smoothness requirements. Straightedge testing and surface corrections shall continue 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. The use of long-handled wood floats shall be confined to a minimum; they may be used only in emergencies and in areas not accessible to finishing equipment.

- f. **Slab Numbering.** Each PCC slab, including stepped slabs, shall be numbered with a unique numeral embossed to a depth of 1/2 inch, in the plastic concrete with a premade stenciling system. The numerals shall be 5 to 6 inches in height. They shall be placed in alignment perpendicular to the taxiway centerline, in the northeast corner of the slab, three feet from each joint. The numbers shall be finished even with the surrounding area, any heaving of PCC resulting from pressing the stencils into the concrete shall be removed leaving a flush finish across the embossed numbers.

The numbering system shall begin at the threshold. It shall indicate the row, starting with numeral "1" followed with a dash and then a numeral indicating the position from left to right. Formatted "1-1", "1-2", "1-3", "1-4", then the second row "2-1", "2-2", "2-3", "2-4" etc.

Each day's work shall record the slab numbers that were poured on that day.

**501-4.12 SURFACE TEXTURE.** The surface of the pavement shall be finished with either a brush or broom finish for all newly constructed concrete pavements. It is important that the texturing equipment not tear or unduly roughen the pavement surface during the operation. The texture shall be uniform in appearance and approximately 1/16 inch in depth. Any imperfections resulting from the texturing operation shall be corrected to the satisfaction of the Engineer.

The finish shall be applied when the water sheen has practically disappeared. The equipment shall operate transversely across the pavement surface.

**501-4.13 CURING.** Immediately after finishing operations are completed and bleed water is gone from the surface, all exposed surfaces of the newly placed concrete shall be cured for a 7-day cure period 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, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 1/2 hour during the curing period.

When a two-saw-cut method is used to construct the contraction joint, the curing compound shall be applied to the saw-cut immediately after the initial cut has been made. The sealant reservoir shall not be sawed until after the curing period has been completed. When the one cut method is used to construct the contraction joint, the joint shall be cured with wet rope, wet rags, or wet blankets. The rags, ropes, or blankets shall be kept moist for the duration of the curing period.

- a. **Impervious membrane method.** Curing with liquid membrane compounds should not occur until bleed and surface moisture has evaporated. All exposed surfaces of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place. The curing compound shall not be applied during rainfall. Curing compound shall be applied by mechanical sprayers under pressure at the rate of one gallon to not more than 150 square feet. 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, the compound shall be stirred continuously by mechanical means. Hand spraying of odd widths or shapes and concrete surfaces exposed by the removal of forms will be permitted. When hand spraying is approved by the Engineer, a double application rate shall be used to ensure coverage. Should the film become damaged from any cause, including sawing operations, within the required curing period, the damaged portions shall be repaired immediately with additional compound or other approved means. Upon removal of side forms, the sides of the exposed slabs shall be protected immediately to provide a curing treatment equal to that provided for the surface.
- b. **White burlap-polyethylene sheets.** The surface of the pavement shall be entirely covered with the sheeting. The sheeting used shall be such length (or width) that it will extend at least twice the thickness of the pavement beyond the edges of the slab. The sheeting shall be placed so that the entire surface and both edges of the slab are completely covered. The sheeting shall be placed and weighted to remain in contact with the surface covered, and the covering shall be maintained fully saturated and in position for seven (7) days after the concrete has been placed.
- c. **Water method.** The entire area shall be covered with burlap or other water absorbing material. The material shall be of sufficient thickness to retain water for adequate curing without excessive runoff. The material shall be kept wet at all times and maintained for seven (7) days. When the forms are stripped, the vertical walls shall also be kept moist. It shall be the responsibility of the Contractor to prevent ponding of the curing water on the subbase.
- d. **Concrete protection for 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 7-day curing period. The Contractor shall be responsible for the quality and strength of the concrete placed during cold weather; and any concrete damaged shall be removed and replaced at the Contractor's expense.
- e. **Concrete protection for hot weather.** Concrete should be continuous moisture cured for the entire curing period and shall commence as soon as the surfaces are finished and continue for at least 24 hours. However, if moisture curing is not practical beyond 24 hours, the concrete surface shall be protected from drying with application of a liquid membrane-forming curing compound while the surfaces are still damp. Other curing methods may be approved by the RPR.

**501-4.14 REMOVING FORMS.** Unless otherwise specified, forms shall not be removed from freshly placed concrete until it has hardened sufficiently to permit removal without chipping, spalling, or tearing. After the forms have been removed, the sides of the slab shall be cured in accordance with Subsection 501-4.13.

If honeycombed areas are evident when the forms are removed, materials, placement, and consolidation methods must be reviewed and appropriate adjustments made to assure adequate consolidation at the edges of future concrete placements. Honeycombed areas that extend into the slab less than approximately 1 inch, shall be repaired with an approved grout, as directed by the Engineer. Honeycombed areas that extend into the slab greater than a depth of 1 inch shall be considered as defective work and shall be removed and replaced in accordance with Subsection 501-4.19.

**501-4.15 SAW-CUT GROOVING.** If shown on the Plans, grooved surfaces shall be provided in accordance with the requirements of Item P-621.

**501-4.16 SEALING JOINTS.** The joints in the pavement shall be sealed in accordance with Item P-605.

**501-4.17 PROTECTION OF PAVEMENT.** The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents until accepted by the Engineer. This shall include watchmen 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, etc. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the Contractor's expense.

Aggregates, rubble, or other similar construction materials shall not be placed on airfield pavements. Traffic shall be excluded from the new pavement by erecting and maintaining barricades and signs until the concrete is at least seven (7) days old, or for a longer period if directed by the Engineer.

In paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment will be permitted on the new pavement after the pavement has been cured for seven (7) days, the joints are protected, the concrete has attained a minimum field cured flexural strength of 450 psi, and the slab edge is protected.

All new and existing pavement carrying construction traffic or equipment shall be kept clean and spillage of concrete and other materials shall be cleaned up immediately.

Damaged pavements shall be removed and replaced at the Contractor's expense. Slabs shall be removed to the full depth, width, and length of the slab.

**501-4.18 OPENING TO CONSTRUCTION TRAFFIC.** The pavement shall not be opened to traffic until test specimens molded and cured in accordance with ATM 506 have attained a flexural strength of 450 psi when tested in accordance with ASTM C78. If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete was placed. Prior to opening the pavement to construction traffic, all joints shall either be sealed or protected from damage to the joint edge and intrusion of foreign materials into the joint. As a minimum, backer rod or tape may be used to protect the joints from foreign matter intrusion.

**501-4.19 REPAIR, REMOVAL, OR REPLACEMENT OF SLABS.** New pavement slabs that are broken or contain cracks or are otherwise defective or unacceptable as defined by acceptance criteria in Subsection 501-6.6 shall be removed and replaced or repaired, as directed by the Engineer, at the Contractor's expense. Spalls along joints shall be repaired as specified. Removal of partial slabs is not permitted. Removal and replacement shall be full depth, shall be full width of the slab, and the limit of removal shall be normal to the paving lane and to each original transverse joint. The Engineer will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be have a diameter of 2 inches to 4 inches, shall be drilled by the Contractor and shall be filled by the Contractor with a well consolidated concrete mixture bonded to the walls of the hole with a bonding agent, using approved procedures. Drilling of cores and refilling holes shall be at no expense to the Department. Repair of cracks as described in this section shall not be allowed if in the opinion of the Engineer the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of cracks shall be allowed in any panel that demonstrates segregated aggregate with an absence of coarse aggregate in the upper 1/8 inch (3 mm) of the pavement surface.

- a. **Shrinkage cracks.** Shrinkage cracks which do not exceed one-third of the pavement depth shall be cleaned and either high molecular weight methacrylate (HMWM) applied; or epoxy resin (Type IV, Grade 1) pressure injected using procedures recommended by the manufacturer and approved by the Engineer. Sandblasting of the surface may be required following the application of HMWM to restore skid resistance. Care shall be taken to ensure that the crack is not widened during epoxy resin injection. All epoxy resin injection shall take place in the presence of the Engineer. Shrinkage cracks which exceed one-third the pavement depth shall be treated as full depth cracks in accordance with Subsections 501-4.19b and 501-4.19c.
- b. **Slabs with cracks through interior areas.** Interior area is defined as that area more than 6 inches (150 mm) from either adjacent original transverse joint. The full slab shall be removed and replaced at no cost to the Owner, when there are any full depth cracks, or cracks greater than one-third the pavement depth, that extend into the interior area.
- c. **Cracks close to and parallel to joints.** All full-depth cracks within 6 inches (either side of the joint and essentially parallel to the original joints, shall be treated as follows.

(1) **Full depth cracks and original joint not cracked.** The full-depth crack shall be treated as the new joint and the original joint filled with an epoxy resin.

- i. **Full-depth crack.** The joint sealant reservoir for the crack shall be formed by sawing to a depth of 3/4 inches,  $\pm 1/16$  inch, and to a width of 5/8 inch,  $\pm 1/8$  inch. The crack shall be sawed with equipment specially designed to follow random cracks. Any equipment or procedure which causes raveling or spalling along the crack shall be modified or replaced to prevent raveling or spalling. The joint shall be sealed with sealant in accordance with P-605 or as directed by the Engineer.
- ii. **Original joint.** If the original joint sealant reservoir has been sawed out, the reservoir and as much of the lower saw cut as possible shall be filled with epoxy resin, Type IV, Grade 2, thoroughly tooled into the void using approved procedures.

If only the original narrow saw cut has been made, it shall be cleaned and pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures.

Where a parallel crack goes part way across paving lane and then intersects and follows the original joint which is cracked only for the remained of the width, it shall be treated as specified above for a parallel crack, and the cracked original joint shall be prepared and sealed as originally designed.

(2) **Full depth cracks and original joint cracked.** If there is any place in the lane width where a parallel crack and a cracked portion of the original joint overlap, the entire slab containing the crack shall be removed and replaced.

- d. **Removal and replacement of full slabs.** Make a full depth cut perpendicular to the slab surface along all edges of the slab with a concrete saw cutting any dowels or tie-bars. Remove damaged slab protecting adjacent pavement from damage. Damage to adjacent slabs may result in removal of additional slabs as directed by the Engineer at the Contractor's expense.

The underlying material shall be repaired, re-compacted and shaped to grade.

Dowels of the size and spacing specified for other joints in similar pavement on the project shall be installed along all four (4) edges of the new slab in accordance with Subsection 501-4.10d.

Placement of concrete shall be as specified for original construction. The joints around the new slab shall be prepared and sealed as specified for original construction.

- e. **Spalls along joints.**

- (1) Spalls less than one inch wide and less than the depth of the joint sealant reservoir, shall be filled with joint sealant material.
  - (2) Spalls larger than one inch and/or deeper than the joint reservoir, but less than 1/2 the slab depth, and less than 25% of the length of the adjacent joint shall be repaired as follows:
    - i. Make a vertical saw cut at least one inch outside the spalled area and to a depth of at least 2 inches. Saw cuts shall be straight lines forming rectangular areas surrounding the spalled area.
    - ii. Remove unsound concrete and at least 1/2 inch of visually sound concrete between the saw cut and the joint or crack with a light chipping hammer. Hydrodemolition, utilizing equipment capable of delivering up to 30,000 psi water pressure, may be used to remove the 1/2-inch of visually sound concrete on the perimeter of the repair area, instead of the light chipping hammer, provided the hydrodemolition effort does not damage sound concrete adjacent to the repair area.
    - iii. Clean cavity with high-pressure water jets supplemented with compressed air as needed to remove all loose material.
    - iv. Apply a prime coat of material recommended by the patch material's manufacturer, to the dry, cleaned surface of all sides and bottom of the cavity, except any joint face in a manner recommended by the manufacturer.
    - v. Fill the cavity with low slump concrete or mortar or with epoxy resin concrete or mortar using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the Engineer. Any spall less than 0.1 cu. ft. shall be repaired only with epoxy resin mortar or a Grade III epoxy resin. Elastomeric concrete shall be used for spalls, not filled with epoxy materials.
    - vi. An insert or other bond-breaking medium shall be used to prevent bond at all joint faces.
    - vii. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints, or as required to be routed for cracks. The reservoir shall be thoroughly cleaned and sealed with the sealer specified for the joints.
  - (3) Spalls deeper than 1/2 of the slab depth or spalls longer than 25% of the adjacent joint require replacement of the entire slab.
- f. **Diamond grinding of Concrete surfaces.** Diamond grinding shall be completed prior to pavement grooving. Diamond grinding of the hardened concrete should not be performed until the concrete is at least 14 days old and has achieved full minimum strength. Equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints will not be permitted. The depth of diamond grinding shall not exceed 1/2 inch and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified.

Diamond grinding shall be performed with a machine specifically designed for diamond grinding capable of cutting a path at least 3 feet wide. The saw blades shall be 1/8-inch wide with sufficient number of flush cut blades that create grooves between 0.090 and 0.130 inches wide; and peaks and ridges approximately 1/32-inch higher than the bottom of the grinding cut. The Contractor shall determine the number and type of blades based on the hardness of the aggregate. Contractor shall demonstrate to the Engineer that the grinding equipment will produce satisfactory results prior to making corrections to surfaces.

Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The slurry resulting from the grinding operation shall be continuously removed and the pavement left in a clean condition. All grinding shall be at the expense of the Contractor.

**501-4.20 SURFACE SEALER.** Apply over the entire surface of the concrete after completing the sealer manufacturer's recommended curing period. Comply with the sealer manufacturer's recommendations for concrete surface preparation, sealer application temperature, rate, and method.

### **CONTRACTOR QUALITY CONTROL (CQC)**

**501-5.1 QUALITY CONTROL PROGRAM.** The Contractor shall develop a Quality Control Program in accordance with GCP Section 100.

**501-5.2 CONTRACTOR QUALITY CONTROL (CQC).** Not Used.

**501-5.3 CONTRACTOR QC TESTING.** The Contractor shall perform all QC tests necessary to control the production and construction processes applicable to this specification and as set forth in the CQCP. The testing program shall include, but not necessarily be limited to, tests for aggregate gradation, aggregate moisture content, slump, and air content. A QC Testing Plan shall be developed and approved by the Engineer as part of the CQCP.

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. Such rejection may be based on only visual inspection. In the event of such 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 such material was erroneously rejected, payment will be made for the material at the contract unit price.

#### **a. Fine aggregate.**

- (1) Gradation.** A sieve analysis shall be made at least twice daily in accordance with ASTM C136 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, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C70 or ASTM C566. If an electronic moisture sensor is used, a control chart shall be produced indicating moisture readings and calibration reports entered for the project records.
- (3) Deleterious substances.** Fine aggregate as delivered to the mixer shall be tested for deleterious substances in fine aggregate for concrete as specified in Subsection 501-2.1b, prior to production of the control strip, and a minimum of every 30-days during production or more frequently as necessary to control deleterious substances.

#### **b. Coarse Aggregate.**

- (1) Gradation.** A sieve analysis shall be made at least twice daily for each size of aggregate. Tests shall be made in accordance with ASTM C136 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, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C566. If an electronic moisture sensor is used, a control chart shall be produced indicating moisture readings and calibration reports entered for the project records.
- (3) Deleterious substances.** Coarse aggregate as delivered to the mixer shall be tested for deleterious substances in coarse aggregate for concrete as specified in Subsection 501-2.1c,

prior to production of the control strip, and a minimum of every 30-days during production or more frequently as necessary to control deleterious substances.

- c. **Slump.** One test shall be made for each subplot. Slump tests shall be performed in accordance with ASTM C143 from material randomly sampled from material discharged from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.
- d. **Air content.** One test shall be made for each subplot. Air content tests shall be performed in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag or other porous coarse aggregate, from material randomly sampled from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.
- e. **Unit weight and Yield.** One test shall be made for each subplot. Unit weight and yield tests shall be in accordance with ASTM C138. The samples shall be taken in accordance with ASTM C172 and at the same time as the air content tests.
- f. **Temperatures.** Temperatures shall be checked at least four times per lot at the job site in accordance with ASTM C1064.
- g. **Smoothness for Contractor Quality Control.** The Contractor shall perform smoothness testing in transverse and longitudinal directions daily to verify that the construction processes are producing pavement with variances less than 1/4 inch in 12 feet, identifying areas that may pond water which could lead to hydroplaning of aircraft. If the smoothness criteria is not met, appropriate changes and corrections to the construction process shall be made by the Contractor before construction continues

The Contractor may use a 12-foot straightedge, a rolling inclinometer meeting the requirements of ASTM E2133, or rolling external reference device that can simulate a 12-foot straightedge approved by the Engineer. Straight-edge testing shall start with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. Testing shall be continuous across all joints. The surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between the two high points. If the rolling inclinometer or external reference device is used, the data may be evaluated using either the FAA profile program, ProFAA, or FHWA profile program ProVal, using the 12-foot straightedge simulation function.

Smoothness readings shall not be made across grade changes or cross slope transitions. The transition between new and existing pavement shall be evaluated separately for conformance with the Plans.

- (1) **Transverse measurements.** Transverse measurements shall be taken for each day's production placed. Transverse measurements shall be taken perpendicular to the pavement centerline each 50 feet or more often as determined by the Engineer. The joint between lanes shall be tested separately to facilitate smoothness between lanes.
- (2) **Longitudinal measurements.** Longitudinal measurements shall be taken for each day's production placed. Longitudinal tests shall be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20 feet; and at the third points of paving lanes when widths of paving lanes are 20 feet or greater. When placement abuts previously placed material the first measurement shall start with one half the length of the straight edge on the previously placed material.

Deviations on the final surface course in either the transverse or longitudinal direction that will trap water greater than 1/4 inch shall be corrected with diamond grinding per Subsection 501-4.19f or by removing and replacing the surface course to full depth. Grinding shall be tapered in



all directions to provide smooth transitions to areas not requiring grinding. All areas in which diamond grinding has been performed shall be subject to the final pavement thickness tolerances specified in Subsection 501-6.6.

Control charts shall be kept to show area of each day's placement and the percentage of corrective grinding required. Corrections to production and placement shall be initiated when corrective grinding is required. If the Contractor's machines and/or methods produce significant areas that need corrective actions in excess of 10 percent of a day's production, production shall be stopped until corrective measures are implemented by the Contractor.

- h. Grade.** Grade will be evaluated prior to and after placement of the concrete surface.

Measurements will be taken at appropriate gradelines (as a minimum at center and edges of paving lane) and longitudinal spacing as shown on cross-sections and Plans. The final surface of the pavement will not vary from the gradeline elevations and cross-sections shown on the Plans by more than 1/2-inch vertically and 0.1 feet laterally. The documentation will be provided by the Contractor to the Engineer by the end of the following working day.

Areas with humps or depression that exceed grade or smoothness and that retain water on the surface must be ground off provided the course thickness after grinding is not more than 1/2-inch less than the thickness specified on the Plans. If these areas cannot be corrected with grinding then the slabs that are retaining water must be removed and replaced in accordance with Subsection 501-4.19d. Grinding shall be in accordance with Subsection 501-4.19f. All corrections will be at the Contractors expense.

**501-5.4 CONTROL CHARTS.** The Contractor shall maintain linear control charts for fine and coarse aggregate gradation, slump, and air content, within limits shown in Table 501-7. The Contractor shall also maintain a control chart plotting the coarseness factor/workability factor from the combined gradations in accordance with Subsection 501-2.1d.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept up to date at all times. As a minimum, the control charts shall identify the project number, the contract 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. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's 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.** The Contractor shall record the running average of the last five gradation tests for each control sieve on linear control charts. Superimposed on the control charts shall be the Action and Suspension Limits. Gradation tests shall be performed by the Contractor per ASTM C136. The Contractor shall take at least two samples per lot to check the final gradation. Sampling shall be per ASTM D75 from the flowing aggregate stream or conveyor belt.
- b. Slump and air content.** The Contractor shall maintain linear control charts both for individual measurements and range (that is, difference between highest and lowest measurements) for slump and air content in accordance with the following Action and Suspension Limits.
- c. Combined gradation.** The Contractor shall maintain a control chart plotting the coarseness factor and workability factor on a chart in accordance with Subsection 501-2.1d.

**TABLE 501-7. CONTROL CHART LIMITS<sup>1</sup>**

Control Parameter	Individual Measurements	
	Action Limit	Suspension Limit
Gradation <sup>2</sup>	*3	*3

Coarseness Factor (CF)	±3.5	±5
Workability Factor (WF)	±2	±3
Slump	+0.5 to -1 inch	+1 to -1.5 inch
Air Content	±1.5%	±2.0%

<sup>1</sup> Control charts shall developed and maintained for each control parameter indicated.

<sup>2</sup> Control charts shall be developed and maintained for each sieve size.

<sup>3</sup> Action and suspension limits shall be determined by the Contractor.

**501-5.5 CORRECTIVE ACTION AT SUSPENSION LIMIT.** The CQCP shall indicate that appropriate action shall be taken when the process is believed to be out of control. The CQCP shall detail what action will be taken to bring the process into control and shall contain 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 suspension limits, immediate steps, including a halt to production, shall be taken to correct the grading.
- b. **Coarseness and Workability factor.** When the CF or WF reaches the applicable suspension limits, the Contractor, immediate steps, including a halt to production, shall be taken to correct the CF and WF.
- c. **Fine and coarse aggregate moisture content.** Whenever the moisture content of the fine or coarse aggregate changes by more than 0.5%, the scale settings for the aggregate batcher and water batcher shall be adjusted.
- d. **Slump.** The Contractor shall halt production and make appropriate adjustments whenever:
  - (1) one point falls outside the Suspension Limit line for individual measurements
  - OR
  - (2) two points in a row fall outside the Action Limit line for individual measurements.
- e. **Air content.** The Contractor shall halt production and adjust the amount of air-entraining admixture whenever:
  - (1) one point falls outside the Suspension Limit line for individual measurements
  - OR
  - (2) two points in a row fall outside the Action Limit line for individual measurements.

### **MATERIAL ACCEPTANCE**

**501-6.1 QUALITY ASSURANCE (QA) ACCEPTANCE SAMPLING AND TESTING.** All acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be directed by the Engineer. The Contractor shall perform the casting and initial curing of the flexural strength specimens as described in Subsection 501-6.5a. After initial curing, the Contractor shall deliver the specimens to the Central Region Materials Laboratory (5750 E. Tudor Road, Anchorage, Alaska), the Northern Region Central Materials Laboratory (2301 Peger Road, Fairbanks, Alaska), or the Southcoast Region Materials Laboratory (6860 Glacier Highway, Juneau, Alaska) for final curing and acceptance testing. The Contractor shall core samples for thickness measurement as described in Subsection 501-6.5b(1) and deliver to the Engineer for measurement. The Contractor shall provide adequate facilities for

the initial curing of beams. The Contractor shall bear the cost of providing initial curing facilities and coring and filling operations, per paragraph 501-6.5b(1).

The samples will be transported while in the molds. The curing, except for the initial cure period, will be accomplished using the immersion in saturated lime water method. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60° to 80°F, 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 using other suitable methods, provided the temperature and moisture loss requirements are met.

**501-6.2 QUALITY ASSURANCE (QA) TESTING LABORATORY.** Quality assurance testing organizations performing these acceptance tests will be accredited in accordance with ASTM C1077. The quality assurance laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods will be submitted to the Engineer prior to start of construction.

**501-6.3 LOT SIZE.** Concrete will be accepted for strength and thickness on a lot basis. A lot will consist of 1,000 cubic yards. Each lot will be divided into five equal sublots. Where three sublots are produced, they will constitute a lot. Where one or two sublots are produced, they will be incorporated into the previous or next lot. Where more than one plant is simultaneously producing concrete for the job, the lot sizes will apply separately for each plant.

**501-6.4 PARTIAL LOTS.** When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot or for overages or minor placements to be considered as partial lots, 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, that is,  $n=5$  or  $n=6$ .

#### **501-6.5 ACCEPTANCE SAMPLING AND TESTING.**

##### **a. Strength.**

(1) **Sampling.** One sample will be taken for each subplot from the plastic concrete delivered to the job site. Sampling locations will be determined by the Engineer in accordance with random sampling procedures contained in ASTM D3665. The concrete will be sampled in accordance with ASTM C172. Beams shall be constructed using rigid steel forms.

(2) **Test Specimens.** The Contractor shall perform the casting and initial curing of specimens in accordance with ATM 506, and shall transport specimens to the Regional Materials Lab, as directed by the Engineer. Final curing will be performed at the Regional Materials Lab. Two (2) specimens will be made from each sample and slump, air content, unit weight, and temperature tests will be conducted for each set of strength specimens. Within 24 to 48 hours, the samples will be transported from the field to the laboratory while in the molds. Samples will be cured in saturated lime water.

The strength of each specimen will be determined in accordance with ASTM C78. The strength for each subplot will be computed by averaging the results of the two test specimens representing that subplot.

(3) **Acceptance.** Acceptance of pavement for strength will be determined by the Engineer in accordance with Subsection 501-6.6b(1). All individual strength tests within a lot will be checked for outliers in accordance with ASTM E178, at a significance level of 5%. Outliers

will be discarded and the remaining test values will be used to determine percentage of material within specification limits (PWL) for acceptance.

**b. Pavement thickness.**

- (1) **Sampling.** One core will be taken by the Contractor for each subplot in the presence of the Engineer. Sampling locations will be determined by the Engineer in accordance with random sampling procedures contained in ASTM D3665. Areas, such as thickened edges, with planned variable thickness, will be excluded from sample locations.

Cores shall be a minimum 4 inch in diameter neatly cut with a core drill. The Contractor will furnish all tools, labor, and materials for cutting samples and filling the cored hole. Core holes will be filled by the Contractor with a non-shrink grout approved by the Engineer within one day after sampling.

- (2) **Testing.** The thickness of the cores will be determined by the Engineer by the average caliper measurement in accordance with ASTM C174. Each core shall be photographed and the photograph included with the test report.

- (3) **Acceptance.** Acceptance of pavement for thickness will be determined by the Engineer in accordance with Subsection 501-6.6.

- c. Yield, Cement Content, and Air Content.** Acceptance of pavement for yield, cement content, and air content will be determined by the Engineer according to Subsection 501-6.6b(8) at the testing rate of 1 test series per 200 cubic yards.

**501-6.6 ACCEPTANCE CRITERIA.**

- a. General.** Acceptance will be based on the following characteristics of the completed pavement discussed in Subsection 501-6.6b:

- (1) Strength
- (2) Thickness
- (3) Grade
- (4) Profilograph smoothness Not used.
- (5) Adjustments for repairs
- (6) Adjustments for grinding
- (7) Dowel bar alignment
- (8) Yield, cement content, and air content

Acceptance for strength, thickness, and grade, will be based on the criteria contained in accordance with Subsections 501-6.6b(1), 501-6.6b(2), and 501-6.6b(3), respectively.

Production quality must achieve 90 PWL or higher to receive full payment.

Strength and thickness will be evaluated for acceptance on a lot basis using the method of estimating PWL. Production quality must achieve 90 PWL or higher to receive full pavement. The PWL will be determined in accordance with procedures specified in Item GCP Section 110.

The lower specification tolerance limit (L) for strength and thickness will be as shown in Table 501-8:

**TABLE 501-8. LOWER SPECIFICATION TOLERANCE LIMIT (L)**

<b>CRITERIA</b>	<b>LOWER TOLERANCE LIMIT</b>
Strength	0.93 × strength specified in Subsection 501-3.3
Thickness	Lot Plan Thickness in inches, - 0.50 in

**b. Acceptance criteria.**

- (1) Strength.** If the PWL of the lot equals or exceeds 90%, the lot will be acceptable. Acceptance and payment for the lot will be determined in accordance with Subsection 501-8.1.
- (2) Thickness.** If the PWL of the lot equals or exceeds 90%, the lot will be acceptable. Acceptance and payment for the lot will be determined in accordance with Subsection 501-8.1.
- (3) Grade.** The final finished surface of the pavement of the completed project will not vary from the gradeline elevations and cross-sections shown on the Plans by more than 1/2-inch vertically or 0.1 feet laterally. The documentation, stamped and signed by a licensed surveyor shall be in accordance with Subsection 501-5.3h. Payment for sublots that do not meet grade for over 25% of the subplot shall be reduced by 5% and not be more than 95%.

The Contractor shall pay the cost of surveying of the level runs that shall be performed by a licensed surveyor. The documentation shall include calculated differences between the planned and finished pavement elevations. The documentation stamped and signed by a licensed surveyor, shall be provided by the Contractor to the Engineer.

The Contractor shall provide to the Engineer at no additional cost, a daily pavement elevation summary presenting the previous day's pavement grades compared to the planned design elevations. The daily summary shall present the differences between the planned grades and the constructed grades at the corners of each numbered panel.

The work area shall be divided into sample lot areas not less than 1,000 square yards unless approved by the Engineer. The lot size for each sample area shall be all the measurements taken within that area.

Sample lines shall be located at the edges and middle of all slabs, at all joints, and at grade breaks. In areas covered by design grading plans the locations of grid sampling points shall match the points shown on the Plans. Additional sample lines shall be located at offsets as determined by the Engineer. The grid angles may be adjusted and grid intervals decreased at the Engineers discretion.

Measurements shall be made at the intersection of all sample lines and as directed by the Engineer.

All measurements shall be recorded in a bound note book. Records for each area's measurements shall include the location, date, air temperature, wind direction and approximate speed, cloud condition, precipitation, and operators' names. Records for each measurement shall include station, offset, and elevation to the nearest 0.01 foot.

- (4) Profilograph roughness for QA Acceptance.** Not used.
- (5) Adjustments for repair.** Sublots with spall repairs, crack repairs, or partial panel replacement, will be limited to no more than 95% payment.
- (6) Adjustment for grinding.** For sublots with grinding over 25% of a subplot, payment will be reduced 5%.

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

**(8) Yield, Cement Content, and Air Content.** Yield, cement content, and air content will be determined according to ATM 504 and ATM 505 and will be evaluated for acceptance based on approved mix design.

**(c) Final Acceptance and Payment.** Final acceptance and payment shall be determined based on a combination of the foregoing factors and such other tests and criteria as shall be necessary to determine before final acceptance and payment that the in-place concrete pavement meets all requirements set forth in this section and the Contract as a whole and represents concrete pavement of the highest quality as required herein. Such additional testing may include but is not limited to petrographic examination conducted pursuant to ASTM C856. Any one or any combination of the following factors in addition to the acceptance criteria set forth herein shall be sufficient cause for precluding final acceptance and rescission of prior interim acceptance:

Concrete which evidences aggregate loss with any risk of foreign object debris (FOD) shall be considered unacceptable. The tolerance for FOD generation shall be considered zero.

**(1)** Concrete which is not of a uniform consistency and/or presents segregation or does not demonstrate even distribution of coarse and fine aggregate particles shall be considered unacceptable.

**(2)** Concrete which is cracked, spalled, raveled or torn shall be considered unacceptable unless it is in the sole judgment of the Engineer repairable as set forth herein.

**METHOD OF MEASUREMENT**

**501-7.1.** Concrete pavement shall be measured by the number of cubic yards of either plain or reinforced pavement as specified in-place, completed and accepted.

**BASIS OF PAYMENT**

**501-8.1 PAYMENT.** Payment for concrete pavement meeting all acceptance criteria as specified in Subsection 501-6.6. Acceptance Criteria shall be based on results of strength, and thickness tests. Payment for acceptable lots of concrete pavement shall be adjusted in accordance with Subsection 501-8.1a for strength and thickness; 501-8.1b for repairs; 501-8.1c for grinding; and 501-8.1d for smoothness, subject to the limitation that:

The total project payment for concrete pavement shall not exceed 105 percent of the product of the contract unit price and the total number of cubic yards of concrete pavement used in the accepted work (See Note 1 under Table 501-9 Price Adjustment Schedule, below).

Payment shall be full compensation for all labor, materials, tools, equipment, and incidentals required to complete the work as specified herein and on the drawings. All costs associated with steel reinforcement, dowel bars, and concrete surface sealer are subsidiary to the Portland cement concrete pavement item.

**a. Basis of adjusted payment.** The pay factor for each individual lot shall be calculated in accordance with the Price Adjustment Schedule in Table 501-9, below. A pay factor shall be calculated for both strength and thickness. The lot pay factor will be the lower of the two pay factors.

**TABLE 501-9  
PRICE ADJUSTMENT SCHEDULE<sup>1</sup>**

<b>Percentage of Materials Within Specification Limits (PWL)</b>	<b>Lot Pay Factor (Percent of Contract Unit Price)</b>
96 – 100	106

Percentage of Materials Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
90 – 95	PWL + 10
75 – 90	0.5 PWL + 55
55 – 74	1.4 PWL – 12
Below 55	Reject <sup>2</sup>

<sup>1</sup> Although it is theoretically possible to achieve a pay factor of 106% for each lot, actual payment in excess of 100% shall be subject to the total project payment limitation specified in Subsection 501-8.1.

<sup>2</sup> The lot shall be removed and replaced unless, after receipt of FAA concurrence, the Owner and Contractor agree in writing that the lot will remain; the lot paid at 50% of the contract unit price; and the total project payment limitation reduced by the amount withheld for that lot.

For each lot accepted, the adjusted contract unit price shall be the product of the lot pay factor for the lot and the contract unit price. Payment shall be subject to the total project payment limitation specified in Subsection 501-8.1. Payment in excess of 100% for accepted lots of concrete pavement shall be used to offset payment for accepted lots of concrete pavement that achieve a lot pay factor less than 100%; except for rejected lots which remain in place and/or sublots with adjustments for repairs.

- b. Adjusted payment for repairs.** The PWL lot pay factor shall be reduced by 5% and be no higher than 95% for sublots which contain repairs in accordance with Subsection 501-4.19 on more than 20% of the slabs within the sublot. Payment factors greater than 100 percent for the strength and thickness cannot be used to offset adjustments for repairs.
- c. Adjusted payment for grinding.** The PWL lot pay factor shall be reduced by 5% and be no higher than 95% for sublots with grinding over 25% of a sublot.
- d. Profilograph Roughness.** Not used.
- e. Payment.** Payment will be made under:

Item P501.010.0000 Portland Cement Concrete Pavement - per cubic yard

## REFERENCES

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

### ASTM International (ASTM)

ASTM A615	Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706	Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A1078	Epoxy-Coated Steel Dowels for Concrete Pavement
ASTM C29	Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C33	Concrete Aggregates
ASTM C70	Surface Moisture in Fine Aggregate
ASTM C78	Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

ASTM C94	Ready-Mixed Concrete
ASTM C117	Materials Finer than 75- $\mu$ m (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C123	Lightweight Particles in Aggregate
ASTM C131	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C138	Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142	Clay Lumps and Friable Particles in Aggregates
ASTM C143	Slump of Hydraulic-Cement Concrete
ASTM C150	Portland Cement
ASTM C171	Sheet Materials for Curing Concrete
ASTM C172	Sampling Freshly Mixed Concrete
ASTM C173	Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C174	Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C231	Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260	Air-Entraining Admixtures for Concrete
ASTM C309	Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C311	Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland Cement Concrete
ASTM C494	Chemical Admixtures for Concrete
ASTM C566	Total Evaporable Moisture Content of Aggregates by Drying
ASTM C618	Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C642	Density, Absorption, and Voids in Hardened Concrete
ASTM C685	Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C856	Petrographic examination of Hardened Aggregate
ASTM C881	Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989	Slag Cement for Use in Concrete and Mortars
ASTM C1064	Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1077	Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1260	Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)



- ASTM C1567 Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
- ASTM C1602 Mixing Water Used in the Production of Hydraulic Cement Concrete
- ASTM D75 Sampling Aggregates
- ASTM D1751 Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
- ASTM D1752 Preformed Sponge Rubber and Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
- ASTM D2419 Sand Equivalent Value of Soils and Fine Aggregate
- ASTM D3665 Random Sampling of Construction Materials
- ASTM D4791 Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
- ASTM E178 Dealing with Outlying Observations
- ASTM E2133 Using a Rolling Inclinometer to Measure Longitudinal and Transverse Profiles of a Traveled Surface

American Concrete Institute (ACI)

- ACI 309R Guide for Consolidation of Concrete

Federal Highway Administration (FHWA)

- HIPERPAV 3, version 3.2

Portland Concrete Association (PCA)

- PCA Design and Control of Concrete Mixtures, 16<sup>th</sup> Edition

American Association of State Highway and Transportation Officials

- AASHTO T 259 Resistance of Concrete to Chloride Ion Penetration

Alaska Test Methods Manual

- ATM 504 WAQTC FOP for AASHTO T 121 Density (Unit Weight), Yield & Air Content (Gravimetric) of Concrete\*.
- ATM 505 WAQTC FOP for AASHTO T 152 Air Content of Freshly Mixed Concrete by the Pressure Method\*
- ATM 506 WAQTC FOP for AASHTO T 23 Making and Curing Concrete Test Specimens in the Field\*

## ITEM P-560 POZZOLONIC CEMENT GROUT

### DESCRIPTION

**560-1.1** Drill holes through existing steel-reinforced portland cement concrete, provide and pump grout into voids observed beneath the slabs. Clean and patch the drilled holes.

### MATERIALS

**560-2.1 GENERAL.** Use a grout mixture and a patch material with the following components proportioned by volume. Obtain test results and approvals as stated.

**560-2.2 POZZOLONIC CEMENT GROUT.** Provide pozzolonic-cement grout consisting of the following:

- a. Portland Cement, type I or II (ASTM C150 or AASHTO M 85)-one part.
- b. Fly-Ash Pozzolon (ASTM C618 or AASHTO M 295)-three parts.
- c. Potable Water as required for fluidity.

Measure fluidity by the Corps of Engineers flow cone method (CRD-C-611). (10-16 seconds efflux time) Additives as needed, such as plasticizers or water reducers.

Submit a 5-pound sample of the proposed grout mixture components. Proportion this total weight according to the proposed mix. Deliver sample materials for testing to the Department Regional Materials Lab. Deliver these materials between 8 am and 4 pm at least 4 weeks before scheduled field use. The test results must show that the components are compatible. If test results do not confirm that the components are compatible, a new submittal of components of a revised mix may be required. Fieldwork will be delayed during the time needed for testing revised mix designs. The required minimum compressive strength is 600 psi, as measured according to ASTM C109 (AASHTO T 106).

**560-2.3 PORTLAND CEMENT PATCH.** Use concrete pavement patch material that consists of the following:

- a. Portland Cement, type I or II -(ASTM C150 or AASHTO M 85)-one part.
- b. Sand-three parts.
- c. Potable Water-the minimum amount needed to moisten the dry components.

The required minimum compressive strength is 600 psi, as measured according to ASTM C109 (AASHTO T 106).

### CONSTRUCTION REQUIREMENTS

**560-3.1** The plan layout was developed from sounding the intact slabs. This layout may be modified in the field, depending on the voids verified or discovered during drilling.

Provide the machinery and labor to accomplish the following sequence. Drill holes using core bits through the existing steel-reinforced concrete pavement. Mix and inject under low pressure the pozzolonic-cement grout into any voids below the slab. Begin injection near the center of slabs and work outwards. Stop pumping if pressures rise or as grout appears in communicating holes. Provide mixing and pumping apparatus, including working gages, hoses and fittings such as nozzles and packers that are needed to complete the task. Place tightly fitted tapering wooden plugs flush with the top of concrete in each hole that is not immediately patched. To patch the slab, clean foreign material, including grout, from boreholes. Redrill to slightly larger diameter, any holes that exhibit spalled edges in the top 1-inch, and tamp them full of patching mixture. Finish patched holes smooth and flush.

## METHOD OF MEASUREMENT

**560-4.1** This item will not be measured for payment.

## BASIS OF PAYMENT

**560-5.1** Payment will be made at the contract lump sum price.

Payment will be made under:

Item P560.010.0000	Pozzolonic Cement Grout – per lump sum
Item P560.020.0000	Portland Cement Grout – per lump sum