SECTION 37 – PORTLAND CEMENT CONCRETE PAVEMENT (FAA P-501)

37-1 GENERAL

The Contractor shall perform all work required by the plans and specifications for construction of jointed plain and reinforced Portland Cement Concrete Pavement for runways, taxiways or aprons, in accordance with Sections 201 and 303 of the Standard Specifications, except as specified otherwise in FAA Specification Item P-501, as included and modified hereafter, and as shown on the Plans.

This item also includes constructing temporary load-bearing surfacing, in the form of temporary panels, steel plating, or other methods, which will provide acceptable levels of support and safety for aircraft traffic between nightly work periods. Such surfacing must satisfy FAA Runway and/or Taxiway Safety Area requirements for smoothness, durability and strength.

ITEM P-501 PORTLAND CEMENT CONCRETE PAVEMENT

DESCRIPTION

501-1.1 *This work shall consist of pavement composed of jointed Portland cement concrete, with reinforcement 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.*

MATERIALS

501-2.1 AGGREGATES.

a. Reactivity. *Aggregates shall be tested for deleterious reactivity with alkalis in the cement, which may cause excessive expansion of the concrete. Tests of coarse and fine aggregate shall be made in accordance with ASTM C 1260. If the expansion of the coarse or fine aggregate test specimens, tested in accordance with ASTM C 1260, does not exceed 0.10 % at 16 days from casting, the coarse or fine aggregates shall be accepted.*

If the expansion at 16 days is greater than 0.10%, tests of combined materials shall be made in accordance with ASTM C 1260 or ASTM C 1567 using the aggregates, cementitious materials, and/or specific reactivity reducing chemicals in the proportions proposed for the mixture design. If the expansion of the proposed combined materials test specimens, tested in accordance with ASTM C 1260 or ASTM C 1567, does not exceed 0.10 % at 30 days from casting, the proposed combined materials will be accepted. If the expansion of the proposed

combined materials test specimens is greater than 0.10% at 30 days, the aggregates will not be accepted unless adjustments to the combined materials mixture can reduce the expansion to less than 0.10 % at 30 days, or new aggregates shall be evaluated and tested.

b. Fine Aggregate. *Fine aggregate shall conform to the requirements of ASTM C 33. Gradation shall meet the requirements of Table 1 when tested in accordance with ASTM C 136, except as may otherwise be qualified under Section 6 of ASTM C 33.*

TABLE 1. GRADATION FOR FINE AGGREGATE (ASTM C 33)	
Sieve Designation (Square Openings)	*Percentage by Weight Passing Sieves*
3/8 in. (9.5 mm)	*100*
No. 4 (4.75 mm)	*95-100*
No. 8 (2.36 mm)	*80-100*
No. 16 (1.18 mm)	*50-85*
No. 30 (600 micro-m)	*25-60*
No. 50 (300 micro-m)	*10-30*
No. 100 (150 micro-m)	*2-10*

c. Coarse Aggregate. *Coarse aggregate shall conform to the requirements of ASTM C 33. Gradation, within the separated size groups, shall meet the requirements of Table 2 when tested in accordance with ASTM C 136. When the nominal maximum size of the aggregate is greater than 1 inch, the aggregates shall be furnished in two size groups.*

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

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

Table 2 *GRADATION FOR COARSE AGGREGATE* *ASTM C 33*	
Sieve Designations (square openings)	***Percentage by Weight Passing Sieves***
in.	*
1-1/2	*100*
1	*95—100*
1/2	*25—60*
No. 4	*0—10*
No. 8	*0—5*

d. Aggregate susceptibility to Disintegration (D) Cracking. *Aggregates that have a history of D-cracking shall not be used. Prior to approval of mixture design and production of Portland cement concrete the Contractor shall submit written certification that the aggregate does not have a history of D-Cracking and that the aggregate meets the specified State requirements.*

(1) *Other sources of crushed stone aggregate shall be approved if the durability factor as determined by ASTM C 666 is greater than or equal to 95 and all other quality test requirements within these specifications are fulfilled. The FAA will consider and reserves final approval of other State classification procedures.*

(2) *Crushed gravel and sand-gravel aggregates shall not be required to meet freeze-thaw durability ratings. These aggregates shall be approved for use in concrete by the state highway agency in the state from which the aggregate originates and the state in which they are to be used and shall meet all other criteria within these specifications.*

e. Aggregate Source*. Fine aggregate shall be from Hanson Quarry, Irwindale, CA, and coarse aggregate shall be from Hanson Quarry, Eagle Valley, CA, unless otherwise approved by the Engineer.*

501-2.2 CEMENT. *Cement shall conform to the requirements of ASTM C-150 Type II or V.*

If for any reason, cement becomes partially set or contains lumps of caked cement, it shall be rejected. Cement salvaged from discarded or used bags shall not be used.

Only cements containing less than 0.6% equivalent alkali or cements that can demonstrate a positive reduction in the expansion created by alkali-silica reactions shall be used. Cement delivered to the job site shall be tested and shall contain not more than 0.05% alkali than that used in the ASTM C 1260 reactivity testing described in Section 501- Testing shall be done on the initial delivery, and not less than once every 2 weeks of production. When eight consecutive tests show acceptable results, test frequency may be increased to once every 4 week, with the Engineer's approval.

501-2.3 CEMENTITIOUS MATERIALS.

a. Fly Ash or Natural Pozzolan. *Fly ash shall meet the requirements of ASTM C 618, Class F with the exception of loss of ignition, where the maximum shall be less than 6 percent for Class F or N. The supplementary optional chemical and physical properties of Table 3 contained in ASTM C 618 shall apply. Fly ash such as is produced in furnace operations utilizing liming materials or soda ash (sodium carbonate) as an additive shall not be acceptable. The Contractor shall furnish vendor's certified test reports for each shipment of Fly Ash used in the project. The vendor's certified test report can be used for acceptance or the material may be tested independently by the Engineer.*

b. Blast Furnace Slag (Slag Cement). *Ground Granulated Blast Furnace (GGBF) slag shall conform to ASTM C 989, Grade 100 or 120. GGBF shall be used only at a rate between 25 and 55 percent of the total cementitious material by mass.*

501-2.4 PREMOLDED JOINT FILLER. *Premolded joint filler for expansion joints shall conform to the requirements of ASTM D 1751 or D 1752, Type II or III and shall be punched to admit the dowels where called for on the plans. Joint filler must be compatible with joint sealants. 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.*

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

501-2.6 STEEL REINFORCEMENT. *Reinforcing shall consist of Welded deformed steel fabric conforming to the requirements of ASTM A 497.*

501-2.7 DOWEL AND TIE BARS. *Tie bars shall be deformed steel bars and conform to the requirements of ASTM A 615 or ASTM A 996, except that rail steel bars, Grade 50 or 60, shall not be used for tie bars that are to be bent or restraightened during construction. Tie bars designated as Grade 40 in ASTM A 615 can be used for construction requiring bent bars.*

Dowel bars shall be plain steel bars conforming to ASTM A 615 or ASTM A 966 and shall be free from burring or other deformation restricting slippage in the concrete. High strength dowel bars shall conform to ASTM A 714, Class 2, Type S, Grade I, II or III, Bare Finish. Before delivery to the construction site each dowel bar shall be painted with one coat of paint conforming to MIL-DTL-24441/20A.SSPC Paint 5 or SSPC Paint 25.Metal or plastic collars shall be full circular device supporting the dowel until the epoxy hardens.

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

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

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

a. *Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C 309, Type 2, Class B, or Class A if wax base only. The proposed curing compound shall satisfy the following requirements:*

(1) Shall maintain relative humidity of concrete surface above 80% for 7 days;

(2) Shall contain white pigment;

(3) Shall be uniform and easily maintained in a thoroughly mixed solution;

(4) Shall form a tough film to withstand early construction traffic.

b. *White polyethylene film for curing concrete shall conform to the requirements of ASTM C 171.*

c. *White burlap-polyethylene sheeting for curing concrete shall conform to the requirements of ASTM C 171.*

d. *Waterproof paper for curing concrete shall conform to the requirements of ASTM C 171.*

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

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

b. Chemical Admixtures. *Water-reducing, set retarding, and set-accelerating admixtures shall meet the requirements of ASTM C 494, including the flexural strength test. High-Range Water Reducing admixtures will not be allowed except for high-early strength concrete mixes.*

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

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

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

MIX DESIGN

501-3.1.1 PROPORTIONS. *Concrete shall be designed to achieve a 28-day flexural strength that meets or exceeds the acceptance criteria contained in paragraph 501-5.2 for a flexural strength of 650 psi, unless otherwise indicated on the plans. The mix shall be designed using the procedures contained in Chapter 9 of the Portland Cement Association's manual, "Design and Control of Concrete Mixtures".*

A separate mix design is required for each flexural strength, and for each type of placement (slipform, side-form, hand placed, etc.), required by the construction sequencing.

The Contractor shall note that to ensure that the concrete actually produced will meet or exceed the acceptance criteria for the specified strength, the mix design average strength must be higher than the specified strength. The amount of overdesign necessary to meet specification requirements depends on the producer's standard deviation of flexural test results and the accuracy that that value can be estimated from historic data for the same or similar materials.

The minimum cementitious material (cement plus fly ash, or GGBFS) shall be 600 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 not be more than 0.45 by weight.

Prior to the start of paving operations and after approval of all material to be used in the concrete, the Contractor shall submit a mix design showing the proportions and flexural strength obtained from the concrete at 7 and 28 days. The mix design shall include copies of test reports, including test dates, and a complete list of materials including type, brand, source, and amount of cement, fly ash, ground slag, coarse aggregate, fine aggregate, water, and admixtures. The fineness modulus of the fine aggregate and the air content shall also be shown. The mix design shall be submitted to the Engineer at least 15 days prior to the start of operations. The submitted mix design shall not be more than 90 days old. Production shall not begin until the mix design is approved in writing by the Engineer.

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

Flexural strength test specimens shall be prepared in accordance with ASTM C 192 and tested in accordance with ASTM C 78. The mix determined shall be workable concrete having a slump in accordance with the following for various methods of placement: 1) slip form construction: ½ inch to 1½ inches; 2) side

form construction: 1 inch to 3 inches; and 3) hand work: 2 inches to 4 inches. Slump requirements will be waived for high-early strength concrete.

501-3.1.2 Combined Aggregate Grading. *The Job Mix Design shall be developed using the procedures contained in Chapter 9 of the Portland Cement Association's manual, "Design and Control of Concrete Mixtures." (see Paragraph 501-3.3.1, this Specification). However, the combined gradation of the aggregates proposed by the mix design effort shall be analyzed to ensure conformance with the Percentage Aggregate Retained Graph, and with the Coarseness Factor/Workability Factor, as outlined below. Proposed mix designs may be rejected for failure to satisfy these combined aggregate gradation requirements even although all other aspects of the mix design may be within specified limits.*

a. Aggregate Grading Controls. *The coarse aggregate, blending sizes (when required), and fine aggregate shall be combined to be graded from the coarse to the fine. Reports of grading shall include sieve sizes 1½", 1", 3/4" ½" 3/8", No.4, No. 8, No. 16, No. 30, No. 50, and No. 100.*

b. Percent Aggregate Retained Graph. *The combined grading shall be plotted on a standard soils gradation graph as the percentage retained for each reporting sieve size versus the considered sieve size. The Y-axis is the percent retained. The X-axis is the sieve size. The plot of the graph should be a smooth curve showing a transition between coarse and fine aggregate. The plot shall not have a significant valley or peak between the 3/8 inch size and the finest reporting sieve size. Information on the grading requirement, and examples of the presentation, is given in US Air Force publication, "Proportioning Concrete Mixtures with Graded Aggregates, A Handbook for Rigid Airfield Pavements".*

This document is available for download at:

http://www.wbdg.org/ccb/AF/AFETL/etl_97_5.pdf

c. Coarseness Factor/Workability Factor. *The combined gradation shall be used to calculate a coarseness factor and a workability factor. The coarseness factor is defined as the percent of combined aggregate retained above the No. 8 sieve which is also retained above the 3/8" sieve. It is calculated by dividing the percent of material retained above the 3/8" sieve by the percent retained above the No. 8 sieve, times 100:*

$$\text{Coarseness Factor} = (100) \times \frac{\text{(\% retained above 3/8 sieve)}}{\text{(\% retained above \#8 sieve)}}$$

The workability factor is defined as the percentage of combined aggregate finer than the No. 8 sieve. The workability factor is increased linearly at a rate of 2.5

units for each 72.5 pounds per cubic yard of cementitious material above or below a baseline cementitious materials content of 564 pounds per cubic yard. If the total cementitious material is 564 pounds per cubic yard, there is no adjustment.

The factors, defined above, shall be plotted on a chart similar to Figure 1, below. The coarseness factor shall not be greater than 75 nor less than 45. The plot of the workability factor and the coarseness factor shall be a single point above the control line and within the workability box defined by the Control lines. The aggregate grading shall be selected to allow for a variance in the stockpile grading based on historical test results from the aggregate source. The Engineer may reject a job mix submittal should he determine that, although the proposed combined aggregate gradation meets the specification requirements, the overlay of historical variability may result in non-conforming gradation during the duration of the project.

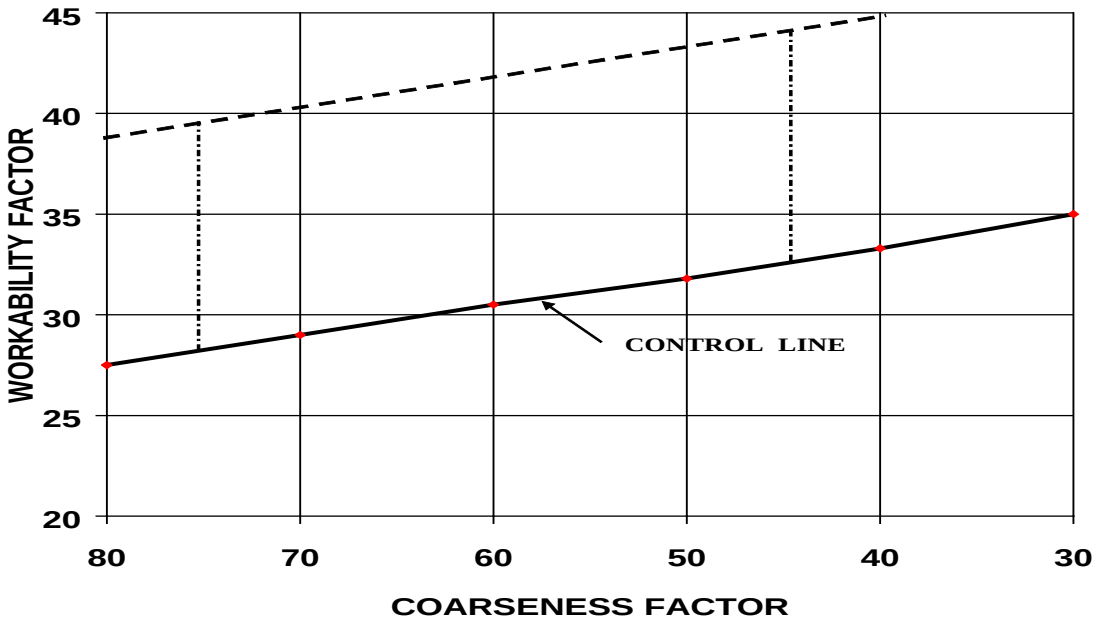

Figure 1 - Aggregate Proportioning Guide

d. Mix Design Format. *The proportioning study shall be provided in report format and will include a graph of the flexural strength versus time (in days) for the selected mixture proportions. Concrete specimens for concrete specified at 28-day strength shall be tested at the ages of 7, 14, and 28 days, minimum. Concrete specimens for concrete specified as high early-strength shall*

be tested hourly as required to determine strength adequacy for the opening to traffic time stipulated on the plans.

501-3.2 CEMENTITIOUS MATERIALS.

a. Fly Ash. *Fly ash may be used in the mix design. When fly ash is used as a partial replacement for cement, the minimum cement content may be met by considering Portland cement plus fly ash as the total cementitious material. The replacement rate shall be determined from laboratory trial mixes, but shall be between 20 and 30 percent by weight of the total cementitious material. If fly ash is used in conjunction with ground granular blast furnace slag the maximum replacement rate shall not exceed 10 percent by weight of total cementitious material.*

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

501-3.3 ADMIXTURES.

a. Air-Entraining. *Air-entraining admixture shall be added in such a manner that will insure uniform distribution of the agent throughout the batch. The air content of freshly mix 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 3%. Air content shall be determined by testing in accordance with ASTM C 231 for gravel and stone coarse aggregate and ASTM C 173 for slag and other highly porous coarse aggregate.*

b. Chemical. *Water-reducing, 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 on trial mixes, with the materials to be used in the work, in accordance with ASTM C 494. Use of high range water reducers will not be allowed for mixes specified by 28-day strength, but may be used for high early-strength mixes.*

501-3.4 TESTING LABORATORY. *The laboratory used to develop the mix design shall meet the requirements of ASTM C 1077. The laboratory accreditation will include ASTM C 78. A certification that it meets these requirements shall be submitted to the Engineer prior to the start of mix design.*

The certification shall include evidence that the laboratory is inspected/accredited for the test methods required herein by a nationally recognized laboratory inspection accreditation organization.

501-3.5 PAVEMENT CONSTRUCTION TEST SECTION. *The Contractor shall construct an 80 feet x 600 feet test section ("test strip") using the materials, equipment and methods he intends to use for the main production for the project. The Test Section shall be constructed at the location, and to the dimensions, lines and grades shown on the plans. It includes joints at the locations, and of the types, shown on the plans. Installation of centerline light cans and conduit will also be required. Grooving of selected slabs of the test section will also be done as part of the approval process, however grooving will not be required until such time as the Contractor is ready to mobilize for grooving of production pavement. At that time, selected slabs of the test section will be grooved, and acceptable performance noted as the standard against which the acceptability of grooving will be judged.*

For high early-strength mixes, the Test Section shall be constructed at the location, and to the dimensions, lines and grades determined by the Engineer. The test section shall be no less than two full slabs in size, using the approved high early-strength concrete mix. The high early-strength pavement shall be placed using the same time duration as will be allowed during actual construction. As part of the high early-strength test section the Contractor shall also place the temporary load bearing surfacing he proposes to use in high early-strength nighttime construction areas.

The intent of the test section is to allow the Contractor to demonstrate that concrete satisfying all project requirements can be batched, mixed, hauled and placed within the specified conditions. The Contractor is expected to adjust the mix, adjust equipment, and modify procedures such that by the end of the test

The Contractor shall obtain written approval of the test section, from the Engineer, before proceeding with the work. If the section, or any part of the test section, is rejected, the cause shall be documented and reasons for rejection provided. The test section approval/rejection will be issued by the Engineer at the end of the day on which the test section is placed. The work will not proceed until the Contractor can demonstrate the placement and finish of an acceptable test section.

Concrete placed within a test section that is not accepted shall be removed and replaced, at the sole expense of the Contractor.

Prior to the use of any placement method other than that used for the approved Test Section, a separate test section will be required for each method of placement (slipform, side-form, hand-placement). Location and size of the test section shall be as directed by the Engineer.

The quality of all aspects of the accepted test section shall be used throughout the project as the standard of quality against which pavement will be judged for acceptability.

CONSTRUCTION METHODS

501-4.1 EQUIPMENT. *Equipment necessary for handling materials and performing all parts of the work shall be approved by the engineer as to design, capacity, and mechanical conditions. The equipment shall be at the jobsite sufficiently ahead of the start of paving operations to be examined thoroughly and approved.*

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

b. Mixers and Transportation Equipment.

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

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

The mixer 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.

(1) Batching Plant Controls. The batching controls shall be either semiautomatic or automatic. Separate bins or compartments shall be provided for each size group of aggregate and for each type of cementitious material to be used. If measured by weight, water shall not be weighed cumulatively with another ingredient, and filling and discharging valves shall be interlocked so that the discharge valve cannot be opened before the filling valve is closed. An accurate mechanical device for measuring and dispensing each admixture shall be provided.

(2) Scales. Scales shall be provided for the accurate measurement and control of each of the materials in each batch of concrete. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other

measuring device. Scales shall be accurate to +/- 0.2% of total scale capacity. Scales shall be tested within each quarter.

(3) Moisture Control. The plant shall be capable of adjustment to compensate for moisture content variations within aggregate stockpiles. Plant shall be capable of controlling water addition to an accuracy of +/- 1% of total mixing water.

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

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

c. Finishing Equipment. *The standard method of constructing concrete pavements on FAA projects shall be with an approved slip-form paving equipment designed to spread, consolidate, screed, and float-finish the freshly placed concrete in one complete pass of the machine so a dense and homogeneous pavement 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. It shall weigh at least 2200 lbs. per foot of paving lane width and powered by an engine having at least 6.0 horsepower per foot of lane width.*

On projects requiring less than 500 square yards of cement concrete pavement or requiring individual placement areas of less than 500 square yards, or irregular areas at locations inaccessible to slip-form paving equipment, cement concrete pavement may be placed with approved placement and finishing equipment utilizing stationary side forms. Hand screeding and float finishing may only be utilized on small irregular areas as allowed by the Engineer.

d. Vibrators. *Vibrator shall be the internal type. Operating frequency for internal vibrators shall be between 8,000 and 12,000 vibrations per minute. Average amplitude for internal vibrators shall be 0.025-0.05 inches.*

The number, spacing, and frequency shall be as necessary to provide a dense and homogeneous pavement and meet the recommendations of ACI 309, 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 be used in irregular areas only, but shall meet the recommendations of ACI 309, Guide for Consolidation of Concrete.

e. 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.*

f. Side Forms. *Straight side forms shall be made of steel and shall be furnished in sections not less than 10 feet in length. Forms shall have a depth equal to the pavement thickness at the edge, and a base width equal to or greater than the depth. Flexible or curved forms of proper radius shall be used for curves of 100-foot radius or less. 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.*

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

h. Drills. *Drills used for drilling dowel openings in previously placed pavement shall be multiple-bit gang-drills capable of drilling multiple dowel openings. Drills shall have necessary controls to ensure accurate alignment and location of the dowels. The Contractor shall maintain a sufficient inventory of spare parts for drills, and a supply of sharp and true drill bits, on site throughout the duration of the paving to ensure that there is no delay to production. The Engineer retains the right to require that equipment and bits be replaced if quality is deemed unacceptable. Bits shall be capable of providing clean and true holes equal in quality to those produced for the accepted Test Section.*

501-4.2 FORM SETTING. *Forms shall be set sufficiently in advance of the concrete placement to insure continuous paving operation. After the forms have*

been set to correct grade, the underlying surface shall be thoroughly tamped, either mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be staked into place sufficiently to maintain the form in position for the method of placement.

Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 1/8 inch at any joint. Forms shall be so set that they will 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 placing of concrete.

The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete.

501-4.3 CONDITIONING OF UNDERLYING SURFACE. *The compacted underlying surface on which the pavement will be placed shall be widened approximately 3 feet to extend beyond the paving machine track to support the paver without any noticeable displacement. After the underlying surface has been placed and compacted to the required density, the areas that will support the paving machine and the area to be paved shall be trimmed or graded to the plan grade elevation and profile by means of a properly designed machine. The grade of the underlying surface shall be controlled by a positive grade control system using lasers, stringlines, or guide wires. If the density of the underlying surface is disturbed by the trimming operations, it shall be corrected by additional compaction and retested at the option of the Engineer before the concrete is placed except when stabilized subbases are being constructed. If damage occurs on a stabilized subbase, it shall be corrected full depth by the Contractor. If traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately before the placement of concrete. The prepared grade shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete. The underlying surface shall be protected so that it will be entirely free of frost when concrete is placed.*

501-4.4 CONDITIONING OF UNDERLYING SURFACE, SIDE-FORM AND FILL-IN LANE CONSTRUCTION. *The prepared underlying surface shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete. Damage caused by hauling or usage of other equipment shall be corrected and retested at the option of the Engineers. If damage occurs to a stabilized subbase, it shall be corrected full depth by the Contractor. A template shall be provided and operated on the forms immediately in advance of the placing of all concrete. The template shall be propelled only by hand and not attached to a tractor or other power unit. Templates shall be adjustable so that they may be set and maintained at the correct contour of the underlying surface. The adjustment and operation of*

the templates shall be such as will provide an accurate retest of the grade before placing the concrete thereon. All excess material shall be removed and wasted. Low areas shall be filled and compacted to a condition similar to that of the surrounding grade. The underlying surface shall be protected so that it will be entirely free from frost when the concrete is placed. The use of chemicals to eliminate frost in the underlying surface shall not be permitted.

The template shall be maintained in accurate adjustment, at all times by the Contractor, and shall be checked daily.

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

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. Rail shipments requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage.

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

501-4.6 MIXING CONCRETE. *The concrete may be mixed at the work site, in a central mix plant or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials, except water, are emptied into the drum. All concrete shall be mixed and delivered to the site in accordance with the requirements of ASTM C 94.*

Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators, or nonagitating trucks. The elapsed time from the addition of cementitious material to the mix until the concrete is deposited in place at the work site shall not exceed 30 minutes when the concrete is hauled in nonagitating trucks, nor 90 minutes when the concrete is hauled in truck mixers or truck agitators. Retempering concrete by adding water or by other means will not be permitted.

With transit mixers additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements provided the addition of water is performed within 45 minutes after the initial mixing operations and provided the water/cementitious ratio specified in the approved mix design is not exceeded, and approved by the Engineer.

501-4.7 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 degrees F (4 degrees C) and shall not be resumed until an ascending air temperature in the shade and away from artificial heat reaches 35 degrees F (2 degrees C).*

The aggregate shall be free of ice, snow, and frozen lumps before entering the mixer. The temperature of the mixed concrete shall not be less than 50 degrees F (10 degrees C) 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 degrees F (66 degrees C). 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.

b. Hot Weather. *During periods of hot weather when the maximum daily air temperature exceeds 85 degrees F (30 degrees C), 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 degrees F (35 degrees C). 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 finished surfaces of the newly laid pavement shall be kept damp by applying a water-fog or mist with approved spraying equipment until the pavement is covered by the curing medium. If necessary, wind screens shall be provided to protect the concrete from an evaporation rate in excess of 0.2 psf per hour as determined in accordance with Figure 2.1.5 in ACI 305R, Hot Weather Concreting, which takes into consideration relative humidity, wind velocity, and air temperature.

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. Such measures shall consist of wind screens, more effective fog sprays, and similar measures commencing immediately behind the paver. If these measures are not effective in preventing plastic cracking, paving operations shall be immediately stopped.

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. 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.*

(3) *Anticipated timing of initial sawing of joint.*

501-4.8 PLACING CONCRETE. *The Contractor has the option of placing the concrete with either side (fixed) forms or slip-forms. 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. Backhoes and Grading equipment shall not be used to distribute the concrete in front of the paver. Front end loaders will not be used unless the contractor demonstrates that they can be used without contaminating the concrete and base course and it is approved by the Engineer.*

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 3,500 psi, based on the average of four field cured specimens per 2,000 cubic yards of concrete placed. Also, subgrade and subbase planers, concrete pavers, and concrete finishing equipment may be permitted to ride upon the edges of previously constructed pavement when the concrete has attained a minimum flexural strength of 400 psi.

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. 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 within 8000 to 12000 cycles per minute 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 an for a distance of at least one foot. The frequency of vibration or amplitude shall vary 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.

b. Side-Form Construction. *Side form sections shall be straight, free from warps, bends, indentations, or other defects. Defective forms shall be removed from the work. Metal side forms shall be used except at end closures and transverse construction joints where straight forms of other suitable material may be used.*

Side forms may be built up by rigidly attaching a section to either top or bottom of forms. If such build-up is attached to the top of metal forms, the build-up shall also be metal.

Width of the base of all forms shall be equal to at least 80 percent of the specified pavement thickness.

Side forms shall be of sufficient rigidity, both in the form and in the interlocking connection with adjoining forms, that springing will not occur under the weight of subgrading and paving equipment or from the pressure of the concrete. The Contractor shall provide sufficient forms so that there will be no delay in placing concrete due to lack of forms.

Before placing side forms, the underlying material shall be at the proper grade. Side forms shall have full bearing upon the foundation throughout their length and width of base and shall be placed to the required grade and alignment of the finished pavement. They shall be firmly supported during the entire operation of placing, compacting, and finishing the pavement.

Forms shall be drilled in advance of being placed to line and grade to accommodate tie 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 oiled each time they are used and before concrete is placed against them.

Concrete shall be spread, screeded, 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.

Concrete for the full paving width shall be effectively consolidated by internal vibrators without causing segregation. Internal type vibrators' rate of vibration shall be not less than 7,000 cycles per minute. Amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete more than one foot from the vibrating element. The Contractor shall furnish a tachometer or other suitable device for measuring and indicating frequency of vibration.

Power to vibrators shall be connected so that vibration ceases when forward or backward motion of the machine is stopped. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than 20 seconds in any one location, nor shall the vibrators be used to move the concrete.

The provisions relating to the frequency and amplitude of internal vibration shall be considered the minimum requirements and are intended to ensure adequate density in the hardened concrete.

c. Consolidation Testing. *The provisions relating to the frequency and amplitude of internal vibration shall be considered the minimum requirements and are intended to ensure adequate density in the hardened concrete. If a lack of consolidation of the concrete is suspected by the Engineer, additional referee testing may be required. Referee testing of hardened concrete will be performed by cutting cores from the finished pavement after a minimum of 24 hours curing. Density determinations will be made based on the water content of the core as taken. ASTM C 642 shall be used for the determination of core density in the saturated-surface dry condition. Referee cores will be taken at the minimum rate of one for each 500 cubic yards of pavement, or fraction thereof.*

The average density of the cores shall be at least 97 percent of the original mix design density, with no cores having a density of less than 96 percent of the original mix design density.

Failure to meet the above requirements will be considered as evidence that the minimum requirements for vibration are inadequate for the job conditions, and additional vibrating units or other means of increasing the effect of vibration shall be employed so that the density of the hardened concrete as indicated by further referee testing shall conform to the above listed 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 such 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 screeded. 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 10-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, without keyways, 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. Expansion. *Expansion 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, except for space for sealant at the top of the slab. The filler shall be securely staked or fastened into position perpendicular to the proposed finished surface. A cap shall be provided to protect the top edge of the filler and to permit the concrete to be placed and finished. After the concrete has been placed and struck off, the cap shall be carefully withdrawn leaving the space over the premolded filler. The edges of the joint shall be finished and tooled while the concrete is still plastic. Any concrete bridging the joint space shall be removed for the full width and depth of the joint.

d. Keyways. *Keyways will not be allowed.*

e. 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. 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. These 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 in the female side of the keyed joint provided the installation is made without distorting the keyed dimensions or causing edge slump. If a bent tie bar installation is used, the tie bars shall be inserted through the keyway liner only on the female side of the joint. In no case shall a bent tie bar installation for male keyways be permitted.*

f. Dowel bars. *Dowel bars or other load-transfer units of an approved type shall be placed across joints in the manner as shown on the plans. They shall be of the dimensions and spacings as shown and held rigidly in the middle of the slab depth in the proper horizontal and vertical alignment by an approved assembly device to be left permanently in place. The dowel or load-transfer and joint devices shall be rigid enough to permit complete assembly as a unit ready to be lifted and placed into position. A metal, or other type, dowel expansion cap or sleeve shall be furnished for each dowel bar used with expansion joints. These caps shall be substantial enough to prevent collapse and shall be placed on the ends of the dowels as shown on the plans. The caps or sleeves shall fit the dowel bar tightly and the closed end shall be watertight.*

The portion of each dowel painted with rust preventative paint, as required under paragraph 501-2.7 and shown on the plans to receive a debonding lubricant, shall be thoroughly coated with asphalt MC-70, or an approved lubricant, to prevent the concrete from bonding to that portion of the dowel. If free-sliding plastic-coated or epoxy-coated steel dowels are used, a lubrication bond breaker shall be used except when approved pullout tests indicate it is not necessary. Where butt-type joints with dowels are designated, the exposed end of the dowel shall be oiled.

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

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

A dowel bar which is placed, found to be defective, and the bonding has set, shall be cut off flush with the pavement edge. A new bar shall be installed not closer than 3, but not more than 6, bar diameters from the specified bar location. When the dowels are defective for more than half of the bars in a slab length, all of the bars shall be cut off and new bars installed at half distance between placed dowels.

Dowels and tie bars shall be placed in longitudinal construction joints by bonding the dowels or tie bars into holes drilled into the hardened concrete. Holes approximately 1/8-inch to 1/4-inch greater in diameter than the dowel or tie bar shall be drilled with rotary-type core drills that must be held securely in place to drill perpendicularly into the vertical face of the pavement slab. Rotary-type percussion drills may be used provided that spalling of concrete does not occur. Any damage of the concrete shall be repaired by the Contractor using a method approved by the Engineer. Dowels or tie bars shall be bonded in the drilled holes using the approved epoxy resin material. Installation procedures shall be adequate to insure that the area around dowels is completely filled with epoxy grout. Epoxy shall be injected into the back of the hole and displaced by the insertion of the dowel bar. Bars shall be completely inserted into the hole and shall not be withdrawn and reinserted creating air pockets in the epoxy around the bar. The Contractor shall furnish a template for checking the position and alignment of the dowels. Dowels (or tie bars) shall be omitted when the center of a dowel will be within one slab thickness or one dowel spacing, whichever is less, from a planned joint, either contraction or construction.

g. Installation. *All devices used for the installation of expansion joints shall be approved by the Engineer.*

The top of an assembled joint device shall be set at the proper distance below the pavement surface and the elevation shall be checked. Such devices shall be set to the required position and line and shall be securely held in place by stakes or other means to the maximum permissible tolerances during the pouring and

finishing of the concrete. The premolded joint material shall be placed and held in a vertical position; if constructed in sections, there shall be no offsets between adjacent units.

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

When concrete is placed using slip-form pavers, dowels and tie bars shall be placed in longitudinal construction joints by bonding the dowels or tie bars into holes drilled into the hardened concrete. Holes approximately 1/8-inch to 1/4-inch greater in diameter than the dowel or tie bar shall be drilled with rotary-type core drills that must be held securely in place to drill perpendicularly into the vertical face of the pavement slab. Rotary-type percussion drills may be used provided that spalling of concrete does not occur. Any damage of the concrete shall be repaired by the Contractor in a method approved by the Engineer. Dowels or tie bars shall be bonded in the drilled holes using an epoxy resin material. Installation procedures shall be adequate to insure that the area around dowels is completely filled with epoxy grout. Epoxy shall be injected into the back of the hole and displaced by the insertion of the dowel bar. Bars shall be completely inserted into the hole and shall not be withdrawn and reinserted creating air pockets in the epoxy around the bar. The Contractor shall furnish a template for checking the position and alignment of the dowels. Dowel bars shall not be less than 10 inches from a transverse joint and shall not interfere with dowels in the transverse direction.

h. Sawing of Joints. *Joints shall be cut as shown on the plans. Equipment shall be as described in paragraph 501-4.1. The circular cutter shall be capable of cutting a groove in a straight line and shall produce a slot at least 1/8 inch (wide and to the depth shown on the plans. The top portion of the slot shall be widened by sawing to provide adequate space for joint sealers as shown on the plans. Sawing shall commence as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing and before uncontrolled shrinkage cracking of the pavement occurs. Sawing shall be carried on both during the day and night as required. The joints shall be sawed at the required spacing, consecutively in sequence of the concrete placement. Curing compound, if being used as the cure type, shall be reapplied in the initial sawcut and maintained for the remaining cure period. Curing compound shall not be applied, and used as the cure method, to any final concrete face that is to receive a sealant. All slurry and debris produced in the sawing of joints shall be removed by immediately by vacuuming and washing and not allowed to dry on the*

pavement surface. Under no conditions will slurry be allowed to enter the storm drain system.

The time of sawing shall vary but shall be done before uncontrolled shrinkage cracking occurs. Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. The sawed faces of joints shall be inspected for undercutting or washing of the concrete caused by early sawing. The saw cut shall not vary more than ½ inch from planned joint alignment. A planned joint shall not be saw cut if a crack has formed near the planned joint location. Sawing of the affected joint shall be discontinued when a crack develops ahead of the saw cut. An adequate number of sawing units shall be provided to complete the sawing before the development of shrinkage cracks. Quality and acceptability of the sawing will be based on comparisons with the accepted test section joints.

Directly after sawing of joints, and before any type of traffic is allowed on the pavement surface, the saw-cut joint shall be protected from moisture loss and debris intrusion. The minimum level of protection is an application of curing compound into the saw-cut, the installation of backer rod and continual sweeping of foreign debris. The Contractor will not allow any traffic on the concrete unless measures are taken to minimize foreign materials from being introduced into saw-cuts. No traffic, of any kind, will be allowed on pavements for which joint protection measures have not been adopted.

After expiration of the minimum concrete curing period specified by the joint seal manufacturer, the upper portion of the groove shall be widened by sawing to the width and depth required for the joint seal reservoir.

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

a. Sequence. *The sequence of operations shall be the strike-off, floating and removal of laitance, straightedging, and final surface finish. The addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted.*

b. Finishing at Joints. *The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material; it shall be firmly placed without voids or segregation under and around all load-transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated as required in paragraph 501-4.8.a. After the concrete has been placed and vibrated adjacent to the joints, the finishing machine shall be operated in a manner to avoid damage or misalignment of joints. If uninterrupted operations of the finishing machine, to, over, and beyond the joints, cause segregation of*

concrete, damage to, or misalignment of the joints, the finishing machine shall be stopped when the screed is approximately 8 inches from the joint. Segregated concrete shall be removed from the front of and off the joint; and the forward motion of the finishing machine shall be resumed. Thereafter, the finishing machine may be run over the joint without lifting the screed, provided there is no segregated concrete immediately between the joint and the screed or on top of the joint.

If slipform paving, The slipform paver shall finish the surface and the paving lane edges as the equipment maintains forward motion. The finishing equipment shall be limited to the paver screed and a float. Floating may be accomplished by hand and by mechanical bull floating. Under no circumstances shall concrete slurry be accumulated on the surface of the finished concrete nor shall concrete slurry be permitted to run down the vertical edges of the placed pavement. Concrete slurry shall not be used to build up along the edges of the concrete to compensate for excessive edge slump.

c. Machine Finishing. *The concrete shall be spread as soon as it is placed, and it shall be struck off and screeded by a finishing machine. The machine shall go over each area as many times and at such intervals as necessary to give to proper consolidation and to leave a surface of uniform texture. Excessive operation over a given area shall be avoided. When side forms are used, the tops of the forms shall be kept clean by an effective device attached to the machine, and the travel of the machine on the forms shall be maintained true without lift, wobbling, or other variation tending to affect the precision finish. During the first pass of the finishing machine, a uniform ridge of concrete shall be maintained ahead of the front screed for its entire length. When in operation, the screed shall be moved forward with a combined longitudinal and transverse shearing motion, always moving in the direction in which the work is progressing, and so manipulated that neither end is raised from the side forms during the striking-off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.*

d. Hand Finishing. *Hand finishing methods will not be permitted, except under the following conditions: in the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade; in areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical. Concrete, as soon as placed, shall be struck off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete when reinforcement is used.*

The screed for the surface shall be a least 2 feet longer than the maximum width of the slab to be struck off. It shall be of approved design, sufficiently rigid to retain its shape, and shall be constructed either of metal or of other suitable

material covered with metal. Consolidation shall be attained by the use of suitable vibrators.

For odd-shaped slabs and concrete constructed after equipment breakdowns, a straightedge and a longitudinal float shall be provided. The handle for each shall be longer than one-half the width of pavement being finished. The longitudinal float shall be at least 12 feet long, of rigid design and construction, and substantially braced as to maintain a plane surface. As soon as placed and vibrated, the concrete shall be struck off, screeded to the crown and cross section detailed, and the entire surface floated.

e. Floating. *After the concrete has been struck off and consolidated, it shall be further smoothed and trued by means of a longitudinal float using one of the following methods:*

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

(2) Mechanical method. *The Contractor may use a machine composed of a cutting and smoothing float(s), suspended from and guided by a rigid frame and constantly in contact with, the side forms or underlying surface. If necessary, long-handled floats having blades not less than 5 feet in length and 6 inches in width may be used to smooth and fill in open-textured areas in the pavement. When the crown of the pavement will not permit the use of the mechanical float, the surface shall be floated transversely by means of a long-handled float. Care shall be taken not to work the crown out of the pavement during the operation. After floating, any excess water and laitance in excess of 1/8-inch thick shall be removed and wasted. Successive drags shall be lapped one-half the length of the blade.*

f. Straight-edge Testing and Surface Correction. *After the pavement has been struck off and while the concrete is still plastic, it shall be tested for trueness with a Contractor furnished 16-foot straightedge swung from handles 3 feet longer than 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 of paragraph 501-5.2e(3). 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.

501-4.12 SURFACE TEXTURE. *The surface of the pavement shall be finished with either a brush or broom, burlap drag, or artificial turf 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. Any imperfections resulting from the texturing operation shall be corrected to the satisfaction of the Engineer.*

a. Brush or Broom Finish. *If the pavement surface texture is to be a type of brush or broom finish, it shall be applied when the water sheen has practically disappeared. The equipment shall operate transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 1/16 of an inch in depth.*

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

c. Artificial Turf Finish. *Section not used.*

501-4.13 SKID-RESISTANT SURFACESSAW-CUT GROOVING. *If shown on the plans, skid resistant surfaces for asphalt pavements shall be provided by construction of saw-cut grooves. Saw-cut grooves must meet the requirements of Item P-621, Saw-cut Grooves, Section 49 of these specifications.*

501-4.14 CURING. *Immediately after finishing operations are completed and marring of the concrete will not occur, the entire surface 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-sawcut method is used to construct the contraction joint, the curing compound shall be applied to the sawcut 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. *The entire surface 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. The curing compound shall be applied by mechanical sprayers with an overlapping coverage in two coats. The total coverage shall not be more than 150 square feet per gallon of curing compound. 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 insure coverage. The curing compound shall be of such character that the film will harden within 30 minutes after application. Should the film become damaged from any cause, including sawing operations, within the required curing period, 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.*

If requested, the Contractor shall remove all curing material by water blasting or light sandblasting at a time allowed by the Engineer to accommodate inspection of slabs for cracks. If within the 7 day curing period, curing compound will be immediately reapplied after inspection at the Contractor's expense.

b. Polyethylene Films. *The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting. The units shall be lapped at least 18 inches. The sheeting shall be placed and weighted to cause it to remain in contact with the surface and sides. The sheeting shall have dimensions that will extend at least twice the thickness of the pavement beyond the edges of the pavement. Unless otherwise specified, the sheeting shall be maintained in place for 7 days after the concrete has been placed. This method will not be approved for use in any areas subject to jet blast.*

c. Waterproof Paper. *The top surface and sides of the pavement shall be entirely covered with waterproofed paper. The units shall be lapped at least 18 inches. The paper shall be placed and weighted to cause it to remain in contact with the surface covered. The paper shall have dimensions that will extend at least twice the thickness of the pavement beyond the edges of the slab. The surface of the pavement shall be thoroughly saturated prior to placing of the paper. Unless otherwise specified, the paper shall be maintained in place for 7 days after the concrete has been placed. This method will not be approved for use in any areas subject to jet blast.*

d. 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 7 days after the concrete has been placed. This method will not be approved for use in any areas subject to jet blast.*

(1) Curing in Cold Weather. *The concrete shall be maintained at a temperature of at least 50 degrees F (10 degrees C) for a period of 72 hours after placing and at a temperature above freezing for the remainder of the curing time. The Contractor shall be responsible for the quality and strength of the concrete placed during cold weather, and any concrete injured by frost action shall be removed and replaced at the Contractor's expense.*

e. 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 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."*

501-4.15 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 as outlined in one of the methods indicated in paragraph 501-4.14. Major honeycombed areas shall be considered as defective work and shall be removed and replaced in accordance with paragraph 501-5.2(f).*

501-4.16 SEALING JOINTS. *The joints in the pavement shall be sealed in accordance with Item P-605, Joint Sealing Filler, Section 42 of these specificaitons..*

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. 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. The Contractor shall have available at all times, materials for the protection of the edges and surface of the unhardened concrete. 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.*

501-4.18 OPENING TO TRAFFIC. *The pavement shall not be opened to traffic until test specimens molded and cured in accordance with ASTM C 31 have attained a flexural strength of 550 pounds per square inch when tested in accordance with ASTM C 78, or a compressive strength of 3,500 psi, when tested in accordance with ASTM C 39. 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. The pavement shall be cleaned before opening for normal operations.*

501-4.19 REPAIR, REMOVAL, REPLACEMENT OF SLABS.

See Section 38 of these specifications, Concrete Repair, Removal and Replacement.

MATERIAL ACCEPTANCE

501-5.1 ACCEPTANCE SAMPLING AND TESTING. *All acceptance sampling and testing will be performed on site by a certified Concrete Testing Laboratory provided by the Contractor. The City of Los Angeles Standards Division technicians shall witness the testing by the Concrete Testing Laboratory. The Engineer shall be permitted unrestricted access to inspect the Contractor's Testing facilities and witness quality control activities and acceptance testing. The Contractor shall be responsible for sampling, curing, handling and testing of concrete beams. Coring for thickness determination necessary to determine conformance with the requirements specified in this section will be performed by the Contractor at locations designated by the Engineer.*

The Concrete Testing Laboratory performing these tests shall meet the requirements of ASTM C1077. The Contractor shall bear the cost of providing curing facilities and on site Concrete Testing Laboratory for all required sampling, curing, strength specimen tests per paragraph 501-5.1(a), and coring and filling operations, per paragraph 501-5.1b(1).

Concrete shall be accepted for strength and thickness on a lot basis. Lots for strength will be evaluated separately for each approved mix design. The Engineer must be present during testing for flexural strength, and thickness measurements will be performed by the Engineer.

A lot shall consist of a day's production not to exceed 3.600 square yards.

Testing organizations performing these tests shall meet the requirements of ASTM C 1077, including accreditation. The accreditation will include ASTM C 78. The Contractor shall bear the cost of providing curing facilities for the strength specimens, per paragraph 501-5.1a(3), and coring and filling operations, per paragraph 501-5.1b(1).

a. Flexural Strength.

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

(2) Testing. *Two (2) specimens shall be made from each sample. Specimens shall be made in accordance with ASTM C 31 and the flexural strength of each specimen shall be determined in accordance with ASTM C 78. The flexural strength for each sublot shall be computed by averaging the results of the two test specimens representing that sublot.*

Immediately prior to testing for flexural strength, the beam shall be weighed and measured for determination of a sample unit weight. Measurements shall be made for each dimension; height, depth, and length, at the mid-point of the specimen and reported to the nearest tenth of an inch. The weight of the specimen shall be reported to the nearest 0.1 pound. The sample unit weight shall be calculated by dividing the sample weight by the calculated volume of the sample. This information shall be reported as companion information to the measured flexural strength for each specimen.

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.

Slump, air content, and temperature tests will also be conducted by the quality assurance laboratory for each set of strength test samples, per ASTM C 31.

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

The Contractor shall take all steps necessary to prevent loss of moisture. Relatively small amounts of surface drying of flexural specimens can induce tensile stresses in extreme fibers that will markedly reduce indicated flexural strength.

The Contractor shall fully control the test beams, on site, from sampling to preparation for testing, including the curing period. When a beam is to be tested, he shall submit the beam to the Concrete Testing Laboratory for testing on site. The Contractor shall supply the certified beam test equipment, approved by the Engineer on site for this testing, and shall provide certification results for the equipment prior to actual testing. The Contractor shall provide testing equipment in a testing trailer.

The Contractor shall provide the Engineer access to the curing facilities and testing equipment at all times, and shall use the testing equipment with the approval of the Engineer.

(4) Acceptance. *Acceptance of pavement for flexural strength will be determined by the Engineer in accordance with paragraph 501-5.2b.*

b. Pavement Thickness.

(1) Sampling. *Each lot shall be divided into four equal sublots and one core shall be taken by the Contractor for each sublot. Sampling locations shall be determined by the Engineer in accordance with random sampling procedures contained in ASTM D 3665. Areas, such as thickened edges, with planned variable thickness, shall be excluded from sample locations.*

Cores shall be neatly cut with a core drill. The Contractor shall furnish all tools, labor, and materials for cutting samples and filling the cored hole. Core holes shall 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 shall be determined by the Engineer by the average caliper measurement in accordance with ASTM C 174.*

(3) Acceptance. *Acceptance of pavement for thickness shall be determined by the Engineer in accordance with paragraph 501-5.2c.*

c. Partial Lots. *When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and Engineer agree in writing to allow 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 shall constitute a lot. Where one or two sublots have been produced, they shall be incorporated into the next lot or the previous lot and the total number of sublots shall be used in the acceptance criteria calculation, i.e., n=5 or n=6.

d. Outliers. *All individual flexural strength tests within a lot shall be checked for an outlier (test criterion) in accordance with ASTM E 178, at a significance level of 5 percent. Outliers shall be discarded, and the PWL shall be determined using the remaining test values.*

501-5.2 ACCEPTANCE CRITERIA.

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

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

Flexural strength and thickness shall be evaluated for acceptance on a lot basis using the method of estimating percentage of material within specification limits (PWL). Acceptance using PWL considers the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results to calculate the percentage of material that is above the lower specification tolerance limit (L).

Acceptance for flexural strength will be based on the criteria contained in accordance with paragraph 501-5.2e(1). Acceptance for thickness will be based on the criteria contained in paragraph 501-5.2e(2). Acceptance for smoothness will be based on the criteria contained in paragraph 501-5.2e(3). Acceptance for grade will be based on the criteria contained in paragraph 501-5.2e(4).

The Engineer may at any time, not withstanding 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.

The Contractor will be required to compile, and keep current, all data relative to the determination of PWL values. Information shall contain, as a minimum:

(1) Layout of Lots and Sublots, per construction phase.

(2) Thickness data per sublot.

(3) Strength data per sublot.

b. Flexural Strength. *Acceptance of each lot of in-place pavement for flexural strength shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher.*

c. Pavement Thickness. ***A****cceptance of each lot of in-place pavement shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher.*

d. Percentage of Material Within Limits (PWL). *The percentage of material within limits (PWL) shall be determined in accordance with procedures specified in Section 110 of the General Provisions.*

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

Lower Specification Tolerance Limit (L)	
Flexural Strength	*0.93 × strength specified in paragraph 501-3.1*
Thickness	*Lot Plan Thickness in inches – 0.50 inches*

e. Acceptance Criteria.

(1) Flexural Strength. *If the PWL of the lot equals or exceeds 90 percent, the lot shall be acceptable. Acceptance and payment for the lot shall be determined in accordance with paragraph 501-8.1.*

(2) Thickness. *If the PWL of the lot equals or exceeds 90 percent, the lot shall be acceptable. Acceptance and payment for the lot shall be determined in accordance with paragraph 501-8.1.*

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

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

(4) Grade. *An evaluation of the surface grade shall be made by the Engineer for compliance to the tolerances contained below. Records shall be maintained showing all grade measurements.*

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

Vertical Deviation. *Vertical deviation from established grade shall not exceed plus or minus 0.04 foot at any point.*

(5) Edge Slump. *When slip-form paving is used, not more than 15 percent of the total free edge of each 500 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; i.e., 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 shall be removed and replaced at the expense of the Contractor when so directed by the Engineer.

If excessive edge slump is detected before initial set of the concrete, the Contractor, with the approval of the Engineer, may attempt a plastic repair. The Engineer will determine if the repair is acceptable. If repeated attempts to repair excessive edge slump are, in the Engineer's opinion, unacceptable, the affected slabs will be removed and replaced at the Contractor's expense. Repeated requests for edge slump repair will not be allowed. Corrective action to preclude future problems must be taken.

The following criteria shall be met for all attempted edge slump repairs:

a) Any additional material to be added to repair the edge slump shall contain a mixture of aggregate and mortar identical to the approved concrete mix. Plain mortar addition will not be allowed.

b) The repair area shall be vibrated into the existing material.

c) After vibration, material shall be screeded and finished as uniformly as possible with the surrounding concrete.

d) The repaired areas shall be textured and cured using the same processes as the surrounding concrete.

e) Repair shall not be attempted after curing compound has been applied .

(6) Dowel Bar Alignment. *Dowel bars and assemblies shall be checked for position and alignment. The maximum permissible tolerance on dowel bar alignment in each plane, horizontal and vertical, shall not exceed 2 percent or 1/4 inch per foot of a dowel bar. Vertical alignment of dowels shall be measured parallel to the designed top surface of the pavement, 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.*

f. Removal and Replacement of Concrete. *Any area or section of concrete that is removed and replaced shall be removed and replaced back to planned joints. The Contractor shall replace damaged dowels and the requirements for doweled longitudinal construction joints in paragraph 501-4.10 shall apply to all contraction joints exposed by concrete removal. Removal and replacement shall be in accordance with Section 38 of these specifications, Concrete Repair, Removal and Replacement.*

CONTRACTOR QUALITY CONTROL

501-6.1 QUALITY CONTROL PROGRAM. *The Contractor shall develop a Quality Control Program in accordance with Section 12 of these specifications (FAA Section 100) of the General Provisions. The program shall address all elements that effect the quality of the pavement including but not limited to:*

a. *Mix Design*

b. *Aggregate Gradation*

c. *Quality of Materials*

d. *Stockpile Management*

e. *Proportioning*

f. *Mixing and Transportation*

g. *Placing and Consolidation*

h. *Joints*

i. *Dowel Placement and Alignment*

j. *Flexural or Compressive Strength*

k. *Finishing and Curing*

l. *Surface Smoothness*

501-6.2 QUALITY CONTROL TESTING. *The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to this specification and as set forth in the Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for aggregate gradation, aggregate moisture content, slump, and air content.*

A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

a. Fine Aggregate.

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

(2) Moisture Content. *If an electric moisture meter is used, 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 C 70 or ASTM C 566.

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 C 136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.*

(2) Moisture Content. *If an electric moisture meter is used, 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 C 566.*

c. Slump. *Four slump tests shall be performed for each lot of material produced in accordance with the lot size defined in Section 501-5.1. One test shall be made for each sublot. Slump tests shall be performed in accordance with ASTM C 143 from material randomly sampled from material discharged from trucks at the paving site. Material samples shall be taken in accordance with ASTM C 172.*

d. Air Content. *Four air content tests, shall be performed for each lot of material produced in accordance with the lot size defined in Section 501-5.1. One test shall be made for each sublot. Air content tests shall be performed in accordance with ASTM C 231 for gravel and stone coarse aggregate and ASTM C 173 for slag or other porous coarse aggregate, from material randomly sampled from trucks at the paving site. Material samples shall be taken in accordance with ASTM C 172.*

e. Unit Weight. *Four unit weight and yield tests shall be made in accordance with ASTM C 138. The samples shall be taken in accordance with ASTM C 172 and at the same time as the air content tests.*

f. Determination of Combined Grading. *The mathematical calculation of the combined aggregate grading, using the proportions selected for the design mixture, shall be used to determine the coarseness and workability factors. Each calculation result shall be plotted on a combined aggregate proportioning guide. Materials which have not been tested for grading shall not be placed in the mixer or incorporated into the work.*

g. Reporting Format*. Each grading test, for each stockpile, shall be plotted on charts which report sieve sizes and the variation from the selected grading. The Contractor shall plot the mathematical combined gradings of the*

results of testing of the stockpiles. The initial point shall be established by the mixture proportioning study. The point may be relocated based upon mixture adjustments made during placement of the test strip. Based upon stockpile samples, any deviation of the point, caused by material variability, which is along a line parallel to the control line of the Aggregate Proportioning Guide, is acceptable.

h. Location of Concrete Sampling. *Concrete samples for testing shall be collected by the Contractor from fresh concrete placed in front of the paver.*

501-6.3 CONTROL CHARTS. *The Contractor shall maintain linear control charts for fine and coarse aggregate gradation, slump, and air content.*

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. Specification limits contained in Tables 1 and 2 shall be superimposed on the Control Chart for job control.*

b. Slump and Air Content. *The Contractor shall maintain linear control charts both for individual measurements and range (i.e. difference between highest and lowest measurements) for slump and air content in accordance with the following Action and Suspension Limits.*

Control Parameter	*CONTROL CHART LIMITS* *Individual Measurements* *Action Limit*	*Suspension Limit*	*Range Suspension Limit*
Slip Form:			
Slump	*+0 to -1 inch*	*+0.5 to -1.5 inch*	*+/- 1.5 inch*
Air Content	*+/- 1.2%*	*+/- 1.8%*	*+/- 2.5%*
Fixed Form			
Slump	*+ 0.5 to -1 inch (13-25mm)*	*+1 to -1.5 inch (25-38mm)*	*+/- 1.5 inch (38mm)*
Air Content	*+/- 1.2%*	*+/- 1.8%*	*+/- 2.5%*

The individual measurement control charts shall use the mix design target values as indicators of central tendency.

501-6.4 CORRECTIVE ACTION. *The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of control. The Contractor Quality Control Program 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 Tables 1 or 2 specification limits, immediate steps, including a halt to production, shall be taken to correct the grading.*

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

c. Slump. *The Contractor shall halt production and make appropriate adjustments whenever:*

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

d. Air Content. *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 range; or*

(2) *two points in a row fall outside the Action Limit line for individual measurements.*

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

501-6.5 REPORTS. *All results of testing, control charts, batch proportions, and other concrete control data shall be maintained in a book, at the*

jobsite with the Engineer, which shall reflect the results of all actions and is current to the preceding twenty-four hours. The Contractor shall report to the Engineer immediately, verbally at incidence, and followed by a written notification, of the breakdown of equipment, test failure reports, or construction deficiencies. Logged information shall include daily temperature, humidity and other pertinent environmental data.

In addition to the record book, the Contractor shall establish a truck load ticket tracking system, acceptable to the Engineer, to allow identification of the location of placement of each load of concrete, and to identify the components of the specific concrete placed. Load tickets shall be delivered to the Engineer for each truck load of concrete delivered. Tickets shall include the date, time, load volume, batch identification number or other information requested by the Engineer, which will allow the particular batch components to be identified. The Engineer will be responsible for noting the placement location on the tickets as delivered to the site.

Data shall be organized to present information on a lot/sublot basis for each construction phase. Test information shall be updated within 24 hours of placement of concrete or receipt of test results, as appropriate..

Gradation testing shall meet the requirements in Section 501-6.2 of these specifications.

METHOD OF MEASUREMENT

***501-7.1 MEASUREMENT**. See Section 37-3.*

BASIS OF PAYMENT

***501-8.1 PAYMENT.** See Section 37-4.*

TESTING REQUIREMENTS

ASTM C 31	*Making and Curing Concrete Test Specimens in the Field*
ASTM C 39	*Compressive Strength of Cylindrical Concrete Specimens*
ASTM C 70	*Surface Moisture in Fine Aggregate*
ASTM C 78	*Test for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)*

ASTM C 88	*Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate*
ASTM C 131	*Test for Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine*
ASTM C 136	*Sieve Analysis of Fine and Coarse Aggregates*
ASTM C 138	*Test for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete*
ASTM C 143	*Test for Slump of Hydraulic Cement Concrete*
ASTM C 172	*Sampling Freshly Mixed Concrete*
ASTM C 173	*Test for Air Content of Freshly Mixed Concrete by the Volumetric Method*
ASTM C 174	*Measuring Thickness of Concrete Elements Using Drilled Concrete Cores*
ASTM C 227	*Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)*
ASTM C 231	*Test for Air Content of Freshly Mixed Concrete by the Pressure Method*
ASTM C 289	*Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)*
ASTM C 295	*Petrographic Examination of Aggregates for Concrete*
ASTM C 114	*Chemical Analysis of Hydraulic Cement*
ASTM C 535	*Test for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*
ASTM C 566	*Total Evaporable Moisture Content of Aggregates by Drying*
ASTM C 642	*Test for Density, Absorption, and Voids in Hardened Concrete*

ASTM C 666	*Resistance of Concrete to Rapid Freezing and Thawing*
ASTM C 1077	*Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction And Criteria for Laboratory Evaluation*
ASTM C 1260	*Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)*
ASTM D 3665	*Random Sampling of Paving Materials*
ASTM D 4791	*Test Method for Flat or Elongated Particles in Coarse Aggregate*
ASTM E 178	*Dealing With Outlying Observations*
ASTM E 1274	*Test for Measuring Pavement Roughness Using a Profilograph*
AASHTO T 26	*Quality of Water to be Used in Concrete*

MATERIAL REQUIREMENTS

ASTM A 184	*Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement*
ASTM A 185	*Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement*
ASTM A 497	*Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement*
ASTM A 615	*Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement*
ASTM A 704	*Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement*
ASTM A 714	*Specification for High-Strength Low-Alloy Welded and Seamless Steel Pipe*

ASTM A 996	*Specification for Rail-Steel and Axle Steel Deformed Bars for Concrete Reinforcement*
ASTM C 33	*Specification for Concrete Aggregates*
ASTM C 94	*Specification for Ready-Mixed Concrete*
ASTM C 150	*Specification for Portland Cement*
ASTM C 171	*Specification for Sheet Materials for Curing Concrete*
ASTM C 260	*Specification for Air-Entraining Admixtures for Concrete*
ASTM C 309	*Specification for Liquid Membrane-Forming Compounds for Curing Concrete*
ASTM C 494	*Specification for Chemical Admixtures for Concrete*
ASTM C 595	*Specification for Blended Hydraulic Cements*
ASTM C 618	*Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete*
ASTM C 881	*Specification for Epoxy-Resin Base Bonding System for Concrete*
ASTM C 989	*Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars*
ASTM D 1751	*Specification for Preformed Expansion Joint Filler for Concrete Paving and Structura Construction (Nonextruding and Resilient Bituminous Types)*
ASTM D 1752	*Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving And Structural Construction*
ACI 305R	*Hot Weather Concreting*
ACI 306R	*Cold Weather Concreting*
ACI 309	*Guide for Consolidation of Concrete*

MIL-DTL-24441/20a Department of Defense	*(1999)_Paint, Epoxy-Polyamide, Green Primer, Formula 150, Type III*

END ITEM P-501

37-2 TEMPORARY LOAD-BEARING SURFACING

Areas of limited night construction are identified on the plans. These construction areas are within the Taxiway and/or Runway Safety Areas of the airport and are subject to operating jet aircraft traffic during daytime hours. Work in these areas will be limited to the hours indicated on the plans and/or in Section 11 - Project Phasing, of these Specifications. The Contractor will be required to provide stable, smooth surfaces in such areas to accommodate aircraft traffic between nightly work shifts.

It is anticipated that concrete pavement work in these areas will require at least two shifts – one for demolition and/or excavation and placement of formwork, and one for placement of high-early strength concrete. The plans include one approved method of providing such temporary surfacing in the form of steel-plated beam structures to cover excavations and formwork. The inclusion of these details in the plans is not to be construed as being the only method of meeting the requirements. The Contractor may submit to the Engineer proposed alternate methods of providing load-bearing capacity, jet-blast resistance and smoothness of grade for these interim periods.

To be considered for approval, proposals must include engineering calculations showing conformance to the following criteria:

37-2.1. Loading

The Contractor shall provide stamped, engineering calculations showing that the surfacing method proposed will withstand aircraft loading up to and including FAA Design Group V aircraft in conformance with the requirements set forth in the Appendices to FAA Advisory Circular 150-5320-6, Pavement Design. Load calculations shall include support for the following aircraft:

(1) Dual-wheel, 48,800# per wheel gear assembly of the Boeing 727; 34 inch center-to-center wheel spacing;

(2) Dual-Tandem (four-wheel), 57,900# per wheel, gear assembly of the Boeing 747-800; 46.8 inch transverse and 56.5 inch longitudinal center-to-center wheel spacing; and

(3) Tridem (six-wheel), 58,900# per wheel, gear assembly of the Airbus A380, 53 inch transverse and 67 inch longitudinal center-to-center wheel spacing.

Contact tire pressure should be assumed to be 221 psi.

37-2.2 Jet Blast

The Contractor shall provide stamped, engineering calculations showing the ability of the proposed temporary surface to withstand jet blast from the outboard engine of the B-747 traveling on the subject taxiway or runway, without producing Foreign Object Debris (FOD) or dust control hazards.

37-2.3 Grade and Smoothness

The proposed method shall satisfy all FAA's Runway and Taxiway Safety Area requirements for smoothness of grade. No lips or drop-offs will be allowed between temporary panels or surfaces and the adjacent pavement, or between new slabs and adjacent pavement. Construction shall not result in lips greater than 1 inch, for pavement traveled by aircraft, or 3 inches, for edges between old and new surfaces at edges and ends not traveled by aircraft. Grades shall be between 0% and -5% measured from the remaining, existing pavement edge.

No work may proceed in these nighttime construction areas until a method of providing temporary load-bearing surfacing has been approved in writing by the Engineer.

If, at any time after the construction of a previously approved method of temporary surfacing, the Engineer determines that the Contractor's methods are not, or are no longer, satisfactory, and/or that there are issues of concern regarding support of loads, jet blast (including potential dust or FOD issues) or that grade criteria are not being met, work in these areas will be stopped. Alternate methods of temporary surfacing that will allow safe daytime operation of aircraft must then be resubmitted and approved before work can restart. No additional contract time will be allowed to the Contractor for delays due to such shutdowns and resubmittals.

Providing such surfacing shall be considered incidental to the construction of the high-early strength concrete pavement, and no separate payment will be made for this work.

37-3 METHOD OF MEASUREMENT

Portland cement concrete pavement shall be measured by the number of cubic yards of either plain or reinforced pavement, constructed as specified, in-place, completed and accepted by the Engineer.

Saw-cut grooving shall be measured and paid under Section 49 of these specifications, Saw-cut Grooves.

37-4 BASIS OF PAYMENT

Payment for accepted concrete pavement shall be made at the contract unit price per square yard, for pavement of the type and thickness indicated in the bid schedule, adjusted in accordance with paragraph 501-8.1a, subject to the limitation that:

The total project payment for concrete pavement shall not exceed **[ ]** percent of the product of the contract unit price and the total number of square yards of concrete pavement used in the accepted work (See Note 2 under Table 3).

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.

* *

The Engineer shall specify a value ranging from 100 percent to 106 percent. When the total project payment for Item P-501 pavement exceeds the contract unit price, any AIP or PFC funds used to pay the excess may require an amendment to the AIP grant or PFC application for the project.

* *

a. Basis of Adjusted Payment. The pay factor for each individual lot shall be calculated in accordance with Table 3. A pay factor shall be calculated for both flexural strength and thickness. The lot pay factor shall be the higher of the two values when calculations for both flexural strength and thickness are 100 percent or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either flexural strength or thickness is 100 percent or higher. The lot pay factor shall be the lower of the two values when calculations for both flexural strength and thickness are less than 100 percent .

TABLE 3. PRICE ADJUSTMENT SCHEDULE [1]

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
96 – 100	106
90 – 95	PWL + 10
75 – 90	0.5PWL + 55
55 – 74	1.4PWL – 12
Below 55	Reject [2]

[1] ALTHOUGH IT IS THEORETICALLY POSSIBLE TO ACHIEVE A PAY FACTOR OF 106 PERCENT FOR EACH LOT, ACTUAL PAYMENT IN EXCESS OF 100 PERCENT SHALL BE SUBJECT TO THE TOTAL PROJECT PAYMENT LIMITATION SPECIFIED IN PARAGRAPH 501-8.1.

[2] The lot shall be removed and replaced. However, the Engineer may decide to allow the rejected lot to remain. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50 percent of the contract unit price AND THE

TOTAL PROJECT PAYMENT LIMITATION SHALL BE REDUCED BY THE AMOUNT WITHHELD FOR THE REJECTED 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 paragraph 501-8.1. Payment in excess of 100 percent 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 percent.

b. Payment. See Section 37-5.

c. Basis of adjusted payment for Smoothness. Price adjustment for pavement smoothness will apply to the total area of concrete within a section of pavement and shall be applied in accordance the following equation and schedule:

(Sq yds in section) x (original unit price per sq yds) x PFm =
reduction in payment for area within section:

Average Profile Index (Inches per mile) pavement strength rating			Contract Unit Price Adjustment PFm
<30,000#	< 30,000#	Short Sections	
0 - 7	0 - 10	0 - 15	0.00
7.1 - 9	10.1 - 11	15.1 - 16	0.02
9.1 - 11	11.1 - 12	16.1 - 17	0.04
11.1 - 13	12.1 - 13	17.1 - 18	0.06
13.1 - 14	13.1 - 14	18.1 - 20	0.08
14.1 - 15	14.1 - 15	20.1 - 22	0.10
15.1 & up	15.1 & up	22.1 & up	corrective work required

Payment shall be made at the contract unit price per plain or reinforced PCC pavement of the type and thickness indicated in the bid schedule. This price shall be full compensation for furnishing all materials, and for all labor, supervision, equipment tools, and incidentals necessary to complete the item.

No separate payment will be made for: constructing the item under construction sequencing restrictions, including limited access or nighttime work area restriction.

Saw-cut grooves will be measured for payment under Section 49 of these specifications.

Payment will be made under:

Item 37.1 Plain PCC Pavement, ____" Thick.....per square yard

Item 37.2 Reinforced PCC Pavement, ____" Thick .....per square yard

Item 37.3 <Item Name> .....per <unit>

END OF SECTION 37

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