READ THIS FIRST

The Engineer shall verify that the latest version of the Federal Aviation Administration Advisory Circular AC 150/5370-10, “Standards for Specifying Construction Of Airports” and that the latest version of the Federal Aviation Administration, Northwest Mountain Region Revision to AC 150/5370-10, “Standards for Specifying Construction Of Airports” are incorporated into this specification.

This Project Spec Document may need additional modifications to suit your project. It is recommended that you proofread each section, paying attention to any “Notes” boxes such as this one--you should remove these “Notes” sections as you go. Also, do a search for all bracket characters “ [ ] “ as they are used to show you areas containing options or project specific details (you can use Microsoft Word’s Find feature {Ctrl-F} to jump to an open bracket “ [ “ character quickly). Again, these bracket characters should be removed.

It is important that every paragraph be numbered to allow for easy referencing. If you use the document’s built in styles and formatting your outline should be fine (turn on the formatting toolbar by going to View > Toolbars > Formatting). Most paragraphs will use the style “Numbered Material” and can be promoted (Shift) or demoted (Shift-Tab).

You should not have to manually enter extra spaces, carriage returns or outline characters such as A, B, C, or 1.01, 1.02; the formatting will do this for you. The entire document is 11 pt. Arial. If you paste items in, you may need to reapply the “Numbered Material” format.

1. GENERAL
   1. SUMMARY OF WORK
      1. The extent and location of “Portland Cement Concrete Pavement (FAA)” Work is shown in the Contract Documents. Portland Cement Concrete (PCC) pavement, constructed on a prepared subgrade or sub-base course, shall be provided in accordance with the provisions of FAA Item P-501, Portland Cement Concrete Pavement, attached hereto.
   2. GOVERNING CODES, STANDARDS, AND REFERENCES
      1. TBD
   3. SUBMITTALS
      1. Submit materials data in accordance with Section 01 33 00 - Submittals. Furnish manufacturers’ technical literature, standard details, product specifications, and installation instructions for all products.
      2. Submittals shall include the following:
2. NOT USED
3. NOT USED
4. NOT USED

End of Section

Revision History:

05/01/2014 Conversion to 2004 CSI Numbering System

10/15/2014 Added Sole Source and Salient Characteristics Note to Part 2 and revisions

# ITEM P-501 PORTLAND CEMENT CONCRETE PAVEMENT

## DESCRIPTION

501-1.1 GENERAL The work set forth in this section consists of the Contractor’s preparation and submittal of an appropriate concrete mix design, including the contractor’s options with respect thereto, discussion of appropriate equipment for use by the Contractor and the placement of pavement composed of 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.

It is the intention of this Section P-501 that all concrete placed shall be in accordance with good construction practices and meet or exceed all standards for quality and durability of airfield pavements of the highest quality.

Section headings used in this Section P-501 or any other part of this Contract are for convenience only and shall not be used in the interpretation of this Section P-501 or any other section or subsection of this Contract so as to indicate that phrases or clauses describing standards, tests, equipment, workmanship, material descriptions, characteristics or results to be achieved are confined to the Section heading under which they appear. Any requirement appearing in one location shall be as binding as if appearing in all. It is the intention of this contract that the work will result in an end concrete product which is dense, homogeneous, without segregation, and which is of the highest quality to meet or exceed all standards of quality in the industry and of the government, with a durability of at least 20 years.

The Engineer shall specify with or without reinforcement.

## MATERIALS

A. If only one product is acceptable (single or sole source product), obtain an approved Competition Waiver and submit to the CPO Construction, Contract Administrator. The language shall read as: “Manufacturer Name, Product # XXXXX, No Equal.” Refer to CPO-6 Competition Waiver Policy for more information.

B. If a Competition Waiver is not approved or more than one product is acceptable, this section must list a minimum of 2 products plus the language “Or Approved Equal,” along with salient characteristics. Refer to CPO Construction’s Salient Characteristics Guidelines for more information.

501-2.1 AGGREGATES.

Reactive aggregates are encountered in the Northwest Mountain Region, and these requirements should be strictly enforced. Testing using ASTM C 1260 and ASTM C 1567 should be based on maximum expansion of 0.10 percent at 28 days in a sodium hydroxide soak solution as specified below:

a. Reactivity: Fine and Coarse aggregates to be used in all concrete shall be evaluated and tested by the Contractor for alkali-aggregate reactivity in accordance with ASTM C 1260. The laboratory conducting the tests shall be accredited under ASTM C 1077. Fine and coarse aggregates shall be evaluated separately in accordance to ASTM C 1260. In addition each aggregate source shall be evaluated separately. Test results that have a measured expansion of less than 0.10 percent at 28 days meet the requirements of these specifications. Should any of the test data indicate an expansion of greater than 0.10 percent, the aggregates shall be rejected or additional testing, by the Contractor utilizing ASTM C 1567 shall be performed.

ASTM C 1567 shall be used to include one of the three options (or approved combinations of the options) below for each individual fine and course aggregates. The test requires at least one comparator reading every 3 or 4 days and a comparator reading at 28 days after the zero reading. The report shall include a graph of percent length change data at each reading from the time of the zero reading to the end of the 28-day period.

(1) Proportioning of Mortar. Utilize the contractor’s proposed low alkali Portland cement and Class "F" flyash in combination for the test proportioning. The laboratory shall use 1 part of cementitious materials (the contractor’s proposed percentage of Portland cement plus flyash) to 2.25 parts of graded aggregate. Use a water-cementitious materials ratio equal to 0.47 by mass. The cementitious material combination shall be determined that will meet all the requirements of these specifications and that which will lower the expansion to less 0.10 percent at 28 days for each individual aggregate. Class "F" flyash shall be used at a minimum rate of 20 percent of the total cementitious material by mass.

(2) Proportioning of Mortar. Utilize the contractor’s proposed low alkali Portland cement and ground granulated blast furnace (GGBF) slag cement in combination for the test proportioning. The laboratory shall use 1 part of cementitious materials (the contractor’s proposed percentage of Portland cement plus GGBF slag) to 2.25 parts of graded aggregate. Use a water-cementitious materials ratio equal to 0.47 by mass. The cementitious material quantity shall be that which will meet all the requirements of these specifications and that which will lower the expansion to less than 0.10 percent at 28 days for each individual aggregate.

(3) Proportioning of Mortar. Utilize a high alkali Portland cement (0.9% total alkali +/- 0.1%) and a lithium nitrate admixture. The lithium nitrate admixture may be used in combination with either Class "F" flyash, Class N pozzolan, or ground granulated blast furnace (GGBF) slag, at a dosage rate as recommended by the supplier.

If Lithium Nitrate is being evaluated, with or without the supplemental cementitious materials, the testing shall be in accordance with COE CRD-C 662.

References:

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 662 (2009) Determining the Potential

Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate

Admixture and Aggregate (Accelerated

Mortar-Bar Method)

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.

The amount of deleterious material in the fine aggregate shall not exceed the following limits by mass:

Material Percentage by Mass

\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Clay lumps and friable particles ASTM C 142 - 1.0

Material finer than 0.075 mm (No. 200 sieve) ASTM C 117 - 3.0

Lightweight particles ASTM C 123 using a medium - 0.5 with a density of 2.0 Mg/cubic meter (Sp. Gr. of 2.0))

Total of all above: 3.0

## 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 μm) | 25-60 |
| No. 50 (300 μm) | 10-30 |
| No. 100 (150 μm) | 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 in, 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 [ ]. 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 Engineer shall specify the Class in accordance with Table 3 of ASTM C 33 or based on historical data. In areas affected by Disintegration Cracking (D-cracking), the Engineer should add ASTM C 666, Resistance of Concrete to Rapid Freezing and Thawing, to the list of testing requirements.

Include Class “5S” for the deleterious materials. This class will limit the potential for Popouts.

Where the elimination of popouts is critical the following table can be used for cold climates instead of the coarse aggregate requirements for deleterious provided in ASTM C 33. Prior to specifying this table aggregate investigations should be made to evaluate source availability.

## LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS

Maximum Percentage by Mass

\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Clay lumps and friable 0.2

particles (ASTM C 142)

Shale (a) (ASTM C 295) 0.1

Material finer than 0.075 mm 0.5

(No. 200 sieve) (b) (ASTM C 117)

Lightweight particles (c) 0.2

(ASTM C 123)

Clay ironstone (d) 0.1

(ASTM C 295)

Chert and cherty stone (less than 0.1

2.40 Mg/cubic meter density SSD

(2.40 Sp. Gr.)) (e)

(ASTM C 123 followed by ASTM C 295)

Claystone, mudstone, and 0.1

siltstone (f) (ASTM C 295)

Shaly and argillaceous 0.2

limestone (g) (ASTM C 295)

Other soft particles 1.0

COE CRD-C 130

Total of all deleterious 1.0

substances exclusive of material finer than 0.075 mm (No. 200 sieve)

a. Shale is defined as a fine-grained, thinly laminated or fissile sedimentary rock. It is commonly composed of clay or silt or both. It has been indurated by compaction or by cementation, but not so much as to have become slate.

b. Limit for material finer than 0.075 mm (No. 200 sieve) will be increased to 1.5 percent for crushed aggregates if the fine material consists of crusher dust that is essentially free from clay or shale.

c. The separation medium shall have a density of 2.0 Mg/cubic meter (Sp. Gr. of 2.0). This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.

d. Clay ironstone is defined as an impure variety of iron carbonate, iron oxide, hydrous iron oxide, or combinations thereof, commonly mixed with clay, silt, or sand. It commonly occurs as dull, earthy particles, homogeneous concretionary masses, or hard-shell particles with soft interiors. Other names commonly used for clay ironstone are "chocolate bars" and limonite concretions.

e. Chert is defined as a rock composed of quartz, chalcedony or opal, or any mixture of these forms of silica. It is variable in color. The texture is so fine that the individual mineral grains are too small to be distinguished by the unaided eye. Its hardness is such that it scratches glass but is not scratched by a knife blade. It may contain impurities such as clay, carbonates, iron oxides, and other minerals. Cherty stone is defined as any type of rock (generally limestone) that contains chert as lenses and nodules, or irregular masses partially or completely replacing the original stone.

f. Claystone, mudstone, or siltstone, is defined as a massive fine-grained sedimentary rock that consists predominantly of indurated clay or silt without laminations or fissility. It may be indurated either by compaction or by cementation.

g. Shaly limestone is defined as limestone in which shale occurs as one or more thin beds or laminae. These laminae may be regular or very irregular and may be spaced from a few inches down to minute fractions of an inch. Argillaceous limestone is defined as a limestone in which clay minerals occur disseminated in the stone in the amount of 10 to 50 percent by weight of the rock; when these make up from 50 to 90 percent, the rock is known as calcareous (or dolomitic) shale (or claystone, mudstone, or siltstone).

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

The Engineer shall specify the percentage of wear. It should not exceed 40 percent. In certain cases where aggregate of this quality cannot be obtained economically, aggregate with a higher percentage of wear may be used if a satisfactory service record of at least 5 years’ duration under similar conditions of service and exposure has been demonstrated.

The Engineer shall specify the aggregate to be furnished from the table shown in this note. The appropriate gradation shall be inserted into Table 2. Insert points are denoted by asterisks. Where locally available aggregates cannot be economically blended to meet the grading requirements, the gradations may be modified by the Engineer to fit the characteristics of such locally available aggregates.

## Gradation For Coarse Aggregate

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sieve Designations (square openings) | | | | | | | Percentage by Weight Passing Sieves | | | | | | |
| From 2” to No. 4 (50.8 mm - 4.75 mm) | | | | From 1 1/2” to No. 4 (38.1 mm - 4.75 mm) | | | | | | From 1” to No. 4 (25.0 mm-4.75 mm) | | | |
| #3  2” – 1” | | #57  1” - No. 4 | | | #4  1 1/2” - ¾” | | | | #67  ¾” - No. 4 | | | #57  1” - No. 4 | |
| in mm | | | | | | |  | | | | | | |
| 2-1/2 | 63 | | 100 | | | --- | | --- | | | --- | | --- |
| 2 | 50.8 | | 90-100 | | | --- | | 100 | | | --- | | --- |
| 1-1/2 | 38.1 | | 35-70 | | | 100 | | 90-100 | | | --- | | 100 |
| 1 | 25.0 | | 0-15 | | | 95-100 | | 20-55 | | | 100 | | 95-100 |
| 3/4 | 19.0 | | --- | | | --- | | 0-15 | | | 90-100 | | --- |
| 1/2 | 12.5 | | 0-5 | | | 25-60 | | --- | | | --- | | 25-60 |
| 3/8 | 9.5 | | --- | | | --- | | 0-5 | | | 20-55 | | --- |
| No. 4 | 4.75 | | --- | | | 0-10 | | --- | | | 0-10 | | 0-10 |
| No. 8 | 2.36 | | --- | | | 0-5 | | --- | | | 0-5 | | 0-5 |

## Table 2 Gradation For Coarse Aggregate (ASTM C)

|  |  |  |  |
| --- | --- | --- | --- |
| **Sieve Designations (square openings)** | | **Percentage by Weight Passing Sieves** | |
| in mm | |  | |
| 2-1/2 | 63 | \* | \* |
| 2 | 50.8 | \* | \* |
| 1-1/2 | 38.1 | \* | \* |
| 1 | 25.0 | \* | \* |
| 3/4 | 19.0 | \* | \* |
| 1/2½ | 12.5 | \* | \* |
| 3/8 | 9.5 | \* | \* |
| No. 4 | 4.75 | \* | \* |
| No. 8 | 2.36 | \* | \* |

Aggregate gradations that produce concrete mixtures with well-graded or optimized aggregate combinations may be substituted for the requirements of Table 1 and Table 2 with prior approval of the Engineer and the FAA. The contractor shall submit complete mixture information necessary to calculate the volumetric components of the mixture.

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.

501-2.2 CEMENT. Cement shall conform to the requirements of ASTM [ ] Type [ ].

The Engineer shall specify one of the following: ASTM C 150 - Type I, II, III, or V.

ASTM C 595 - Type IP, IS.

ASTM C 1157 – Types GU, HE, HS, MH, LH

ASTM C 150 covers Portland cements.

ASTM C 595 covers blended hydraulic cements as follows: IP - Portland-Pozzolan Cement, IS - Portland Blast-Furnace Slag Cements.

ASTM C 1157 covers the following hydraulic cements: General Use (GE), High-Early Strength (HE), Moderate Sulfate Resistance (MS), High Sulfate Resistance (HS), Moderate Heat of Hydration (MH), and Low Heat of Hydration (LH).

The chemical requirements for all cement types specified should meet suitable criteria for deleterious activity in accordance with ASTM C 33 or based on historical data. Low alkali cements (less than 0.6% total equivalent alkalinity, the low reactivity option in ASTM C 595, or Option R in ASTM C 1157) should be specified when any doubt exists.

Total Alkalis (Na2O and K2O) of the cement secured for the production of concrete shall be independently verified in accordance with ASTM C 114.

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.

501-2.3 CEMENTITIOUS MATERIALS.

a. Flyash or Natural Pozzolan. Flyash shall meet the requirements of ASTM C 618, Class F or N with the exception of loss of ignition, where the maximum shall be less than 6 percent. [The following tests in Supplementary Optional Physical Requirements of Table 3 contained in ASTM C 618 shall apply: Select the appropriate tests when project specific conditions or exposures dictate (Increase of drying shrinkage of mortar bar); (Effectiveness in Contributing to Sulfate Resistance Procedure A) or (Effectiveness in Contributing to Sulfate Resistance Procedure B). Select either sulfate resistance test, but not both.] Class F or N flyash for use in mitigating alkali-silica reactivity shall have a Calcium Oxide (CaO) content of less than 13 percent and a total equivalent alkali content less than 3 percent. Flyash such as is produced in furnace operations using liming materials or soda ash (sodium carbonate) as an additive shall not be acceptable. The Contractor shall furnish the previous three most recent, consecutive ASTM C-618 reports for each source of flyash proposed in the mix design, and shall furnish each additional report as they become available during the project. The reports can be used for acceptance or the material may be tested independently by the Engineer.

Class C flyash may be proposed on a case-by-case basis where innocuous aggregates are used and the pavement is not subjected to airfield pavement de-icers. Any use of Class C flyash is subject to the approval of the engineer and FAA. A modification to standards will be required.

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.

GGBFS (slag cement) must be permitted at the contractor’s option, unless its use can be determined to be inappropriate for technical reasons documented by the owner or the design engineer.

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

The Engineer shall designate either ASTM D 1751 or ASTM D 1752. Joint filler must be compatible with joint sealants.

501-2.5 JOINT SEALER. The joint sealer for the joints in the concrete pavement shall meet the requirements of [Item P-604] [Item P-605] and shall be of the type specified in the plans.

501-2.6 STEEL REINFORCEMENT. Reinforcing shall consist of [ ] conforming to the requirements of ASTM [ ].

The Engineer shall designate one of the following:

ASTM A 185, Welded steel wire fabric

ASTM A 497, Welded deformed steel fabric

ASTM A 184 or A 704, Bar mats

Welded wire fabric shall be furnished in flat sheets only.

Delete this paragraph when not applicable to the project.

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 in (50 mm to 75 mm) of the dowel, with a closed end and with a suitable stop to hold the end of the bar at least 1 in (25 mm) 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.

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.

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

501-2.12 MATERIAL ACCEPTANCE. Prior to use of materials, 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 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.-3.0 MIX DESIGN. The mix design for all Portland Cement Concrete to be placed under this Section P-501 shall be prepared and tested by a qualified laboratory and shall be certified by the stamp or seal of the responsible professional retained by the Contractor who is in charge of and responsible for the mix design. Certification shall constitute a warranty that the materials selected and the proportions proposed by the Contractor are in full compliance with this Section P-501 and when properly placed with good workmanship and appropriate construction means, methods and techniques as specifically contemplated by the Contractor under this AIP Contract will result in a concrete meeting or exceeding the requirement of the specifications and of the finished product after taking into account all of the conditions associated with such compliance, including the requirement, if any, for grooving of the pavement surface in order to obtain a skid-free surface.

The inclusion of specific aggregates, cement, additive or other allowed materials within this section shall not require the use of any specific material. The selection of materials and proportions is for the Contractor and its certifying professional to determine in order to achieve the requirements set forth herein, including but not limited to the requirements of Section P-501-5.2.

No work shall be placed until the mix design has been submitted to the Engineer for review and the engineer has reviewed and taken appropriate action with respect thereto. The Engineer’s review shall be for the limited purpose of checking whether the materials selected by the Contractor and certifying professional are permitted or allowed in this section and shall not relieve the Contractor and certifying professional of the responsibility to select and proportion the materials chosen so as to achieve the intent of this Section P-501, which is to require the placement of a completed pavement that in all respects meets the highest standards and requirements for rigid concrete pavements of the highest quality. The Engineer’s review shall not indicate acceptance or approval of the material proportions or of the specific interactions of such materials as proportioned or of the Contractor’s selected means, methods, techniques, sequences or procedures, all of which remain the responsibility of the Contractor. Approval by the Engineer of specific materials as complying with this Section shall not indicate a representation that the materials and proportions selected will result in an acceptable completed pavement. The responsibility for such assurance remains that of the Contractor and its certifying professional.

Certification by the Contractor’s mix design professional shall be a specific warranty that such professional in determining the materials and proportions has considered the appropriateness thereof for use with the specific equipment and means and methods intended for use by the Contractor.

501-3.1 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 [ ] psi. 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”.

The Engineer shall designate the design strength. Refer to AC 150/5320-6 for guidance when specifying flexural strength. The minimum flexural strength allowable for airport pavements is 600 psi (4 136 kPa).

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

For pavements designed to accommodate aircraft gross weights of 30,000 pounds (13 500 kg) or less, this section may be modified to indicate that concrete shall be designed to achieve a 28-day compressive strength such that meets or exceeds the acceptance criteria for a compressive strength of 4,400 psi (3,700 kPa).

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

The flexural design strength specified shall not exceed 650 psi unless it is approved by the FAA Airport District Office. Approval will be based on evidence that local materials can be utilized to consistently produce above the lower design strength limit.

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 flyash, or GGBFS) shall be [ ] pounds per cubic yard ([ ] kg per cubic meter). The ratio of water to cementitious material, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates shall not be more than [ ] by weight.

A minimum cementitious material content of 564 pounds (227 kg) should be specified. A higher minimum may be necessary to meet the specified strength when other cementitious materials are substituted or to meet durability requirements for severe freeze/thaw, de-icer, or sulfate exposure.

A maximum water/cementitious ratio of 0.45 should be specified. A lower water/cementitious ratio may be necessary for severe freeze/thaw, de-icer, or sulfate exposure.

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, flyash, 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 [ ] 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.

A minimum of 10 days is recommended.

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 for side-form concrete between 1 and 2 in (25 mm and 50 mm) as determined by ASTM C 143. For vibrated slip-form concrete, the slump shall be between 1/2 in (13 mm) and 1 1/2 in (38 mm).

When the design strength in paragraph 501-3.1 is based on compressive strength, the specimens should be tested in accordance with ASTM C 39. Substitute compressive strength for flexural strength.

501-3.2 CEMENTITIOUS MATERIALS.

a. Flyash. Flyash may be used in the mix design. When flyash is used as a partial replacement for cement, the minimum cement content may be met by considering Portland cement plus flyash 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 flyash 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 flyash if both are used, may constitute between 25 to 55 percent of the total cementitious material by weight. If the concrete is to be used for slipforming operations and the air temperature is expected to be lower than 55 °f (13 °c) the percent slag shall not exceed 30 percent by weight.

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

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

501-3.3 ADMIXTURES

a. Air-Entraining. 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 [ ]. 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.

The Engineer shall specify the appropriate air content as determined from the table in this note. For warm climate areas where freezing and thawing are not a factor, non-air-entrained concrete may be used.

## Recommended Air Content (Percent)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Exposure Level** | **Maximum Size Aggregate in (mm)** | | | | |
|  | 2”  (51 mm) | 1½”  (38 mm) | 1”  (25 mm) | ¾”  (19 mm) | ½”  (13 mm) |
| Mild | 2.0% | 2.5% | 3.0% | 3.5% | 4.0% |
| Moderate | 4.0% | 4.5% | 4.5% | 5.0% | 5.5% |
| Severe | 5.0% | 5.5% | 6.0% | 6.0% | 7.0 % |

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

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

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

501-3.4 CONCRETE MIX DESIGN LABORATORY. The Contractor’s laboratory used to develop and certify the concrete mix design shall meet the requirements of ASTM C 1077. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for developing the concrete mix design must be listed on the lab accreditation. A copy of the laboratory’s current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

## CONSTRUCTION METHODS

501-4.0 GENERAL The selection of equipment and the means, methods, techniques and sequences necessary to achieve finished pavement meeting or exceeding the requirements of this Section P-501 shall be the responsibility of the Contractor. The Contractor may propose any combination of equipment and means and methods which in the opinion of the Contractor will be enable it to achieve the required results whether such equipment, means and methods are listed in this Section or not. Equipment referenced in this section is included based on the experience of the Engineer on similar projects and is not an indication that use of such equipment on the work required under this AIP Contract is required or will result in an acceptable finished product. Approval of the Contractor’s selected equipment shall not indicate an approval of the Contractor’s means, methods, techniques or sequences, which remain the responsibility of the Contractor, and does not constitute or indicate a review of the operating condition of the equipment or the skill, training or capabilities of the Contractor’s operators or work force.

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 condition. However, operation of the equipment as well as training and supervision of the persons operating the equipment remain at all times with the Contractor. 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.

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

(2) Central plant mixer. Central plant mixers shall conform to the requirements of ASTM C 94. 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 in (19 mm) or more. The Contractor shall have a copy of the manufacturer’s design on hand showing dimensions and arrangement of blades in reference to original height and depth.

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

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

c. Finishing Equipment. The standard method of constructing concrete pavements and a standard for acceptance shall be with an approved slip-form paving equipment designed and skillfully operated so as to spread, consolidate, screed, and float-finish the freshly placed concrete in one complete pass of the machine such that the end result is a dense and homogeneous pavement which is achieved with a minimum of hand finishing. The paver-finisher shall be a heavy duty, self-propelled machine designed specifically for paving and finishing high quality concrete pavements. 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 in (0.06 - 0.13 cm).

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 (3 m) 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 ft (31 m) 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 in (3 mm) in 10 ft (3 m), and the upstanding leg shall not vary more than 1/4 in (6 mm). The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when approved by the Engineer.

g. Pavers. 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.

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 in (3 mm) 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 ft (1 m) to extend beyond the paving machine track to support the paver without any noticeable displacement. After the underlying surface has been placed and compacted to the required density, 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.

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

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 from different sources shall be stockpiled, weighed and batched separately at the concrete batch plant.

Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. 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 non-agitating 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 non-agitating 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 °F (4 °C) and shall not be resumed until an ascending air temperature in the shade and away from artificial heat reaches 35 °F (2 °C).

The aggregate shall be free of ice, snow, and frozen lumps before entering the mixer. The temperature of the mixed concrete shall not be less than 50 °F (10 °C) at the time of placement. Concrete shall not be placed on frozen material nor shall frozen aggregates be used in the concrete.

When concreting is authorized during cold weather, water and/or the aggregates may be heated to not more than 150 °F (66 °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.

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

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

The forms and/or the underlying surface shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 90° F (35 °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 ft (1 m). Regardless of the manner of placing the concrete, the finished concrete product must be dense and homogeneous, without segregation and conforming to the standards set forth in this Contract. 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 (3,792 kPa) ] [ a compressive strength of 3,500 psi ], based on the average of four field cured specimens per 2,000 cubic yards (1,530 cubic meters) 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.

The Engineer shall choose based on mix design requirement. The Engineer may specify either side form or slip-form method of paving or allow the Contractor the option as indicated.

a. Slip-Form Construction. The concrete shall be distributed uniformly into final position by a self-propelled slip-form paver without delay. The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose. The paver shall vibrate the concrete for the full width and depth of the strip of pavement being placed and the vibration shall be adequate to provide a consistency of concrete that will stand normal to the surface with sharp well defined edges. The sliding forms shall be rigidly held together laterally to prevent spreading of the forms.

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

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 and for a distance of at least 1 ft. 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 1 ft 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.

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 in (13 mm) from their designated position and shall be true to line with not more than 1/4 in (6 mm) variation in 10 ft (3 m). The surface across the joints shall be tested with a 10 ft (3 m) straightedge as the joints are finished and any irregularities in excess of 1/4 in (6 mm) 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 with or 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 in (3 mm) 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.

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

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

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

e. Tie bars. Tie bars shall consist of deformed bars installed in joints as shown on the plans. 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. Where butt-type joints with dowels are designated, the exposed end of the dowel shall be oiled.

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.

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 pre-molded 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. Grout disks may be necessary to retain the grout in the hole until it hardens. Any dowels with voids in the grout shall be cut off and a new dowel installed next to it.

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 in to 1/4 in (3 to 6 mm) 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 installed less than 6 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 in (3 mm) 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. Paragraph 501-4.10 h: Early-entry saws may be used, subject to demonstration and approval of the Engineer. No change to the sawcut depth shall be permitted, however the total cut depth can be accomplished on a two-step process but within 24 hours of placement. 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 vacuuming and washing.

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 in (20 cm) 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.

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 (0.6 m) longer than the maximum width of the slab to be struck off. It shall be of approved design, sufficiently rigid to retain its shape, and shall be constructed either of metal or of other suitable material covered with metal. Consolidation shall be attained by the use of suitable vibrators.

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 (3.6 m) in length and 6 in (15 cm) 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 in (3 mm) thick shall be removed and wasted.

(2) Mechanical method. The Contractor may use a machine composed of a cutting and smoothing floats, suspended from and guided by a rigid frame and constantly in contact with, the side forms or underlying surface. If necessary, long-handled floats having blades not less than 5 feet (1.5 m) in length and 6 in (15 cm) 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 in (3 mm) 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 ft (5 m) straightedge swung from handles 3 feet (1 m) 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 in (3 mm) 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 1 in (2 mm) 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 (555 grams per square meter). To obtain a textured surface, the transverse threads of the burlap shall be removed approximately 1 ft (0.3 m) from the trailing edge. A heavy buildup of grout on the burlap threads produces the desired wide sweeping longitudinal striations on the pavement surface. The corrugations shall be uniform in appearance and approximately 1/16 in (2 mm) in depth.

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

The Engineer may specify a particular type of finish or allow the Contractor the option.

501-4.13 SKID RESISTANT SURFACES. A skid resistant surface shall be provided by construction of saw cut grooves, per Item P-621. Submission of the mix design as required by this Section P-501 shall constitute a warranty by the Contractor and certifying professional that the mix design, including the hardness and other characteristics of the selected aggregate, as well as other mix design characteristics including the adequacy of the paste to aggregate bond, are appropriate for the Contractor’s proposed grooving operations, including but not limited to the means, methods, techniques and sequences to be used in grooving. It shall be the specific obligation of the Contractor to determine the time from placement to grooving that will in combination with proper materials and placement result in a completed, grooved surface that remains firm and in-tact without tearing, raveling, dislodgment or loss of aggregate on the surface of the grooved panels.

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.

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

The use of supplementary cementitious materials (for example, flyash, slag cement) or set-retarding admixtures may delay the occurrence of bleed water. Curing should be applied after bleed water is gone from the surface.

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. Curing compound shall be applied by mechanical sprayers under pressure at the rate of 1 gallon (4 liters) to not more than 150 sq ft (14 sq m). 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. The use of flyash or set-retarding admixtures may delay the occurrence of bleed water. Curing shall be applied after the bleed water is gone from the surface.

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 in (457 mm). 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.

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 in (457 mm). 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.

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.

(1) Curing in Cold Weather. The concrete shall be maintained at a temperature of at least 50 °F (10 °C) for a period of 72 hours after placing and at a temperature above freezing for the remainder of the curing time. 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].

The Engineer should only include the applicable specifications.

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 (0.1 mm) thick of sufficient length and width to cover the plastic concrete slab and any edges. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the plastic concrete surface. When rain appears imminent, all paving operations shall stop and all available personnel shall begin covering the surface of the unhardened concrete with the protective covering. Damaged pavements shall be removed and replaced at the contractor’s expense. Slabs shall be removed to the full depth, width, and length of the slab. The Engineer may evaluate the damage to determine if diamond grinding can correct the surface and provide the required smoothness, grade, and thickness required by the contract.

All embedments in the pavement surface shall be made by diamond coring or sawing in a manner that will not chip or spall the surface.

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 lb / sq in (3,792 kPa) when tested in accordance with ASTM C 78. 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.

When the design strength in paragraph 501-3.1 is based on compressive strength, a strength of 3500 psi (24 130 kPa) shall be specified. Testing shall be in accordance with ASTM C 39.

501-4.19 REPAIR, REMOVAL, REPLACEMENT OF SLABS.

a. General. New pavement slabs that are broken or contain cracks or are otherwise defective or unacceptable shall be removed and replaced or repaired, as specified hereinafter at no cost to the owner. Spalls along joints shall be repaired as specified. Removal of partial slabs is not permitted. Removal and replacement shall be full depth, shall be full width of the slab and the limit of removal shall be normal to the paving lane and to each original joint. The Engineer will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be 4-inch (100 mm) diameter, shall be drilled by the Contractor and shall be filled by the Contractor with a well consolidated concrete mixture bonded to the walls of the hole with epoxy resin, using approved procedures. Drilling of cores and refilling holes shall be at no expense to the owner. All epoxy resin used in this work shall conform to ASTM C 881, Type V. Repair of cracks as described in this section shall not be allowed if in the opinion of the Engineer the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of cracks shall be allowed in any panel that demonstrates segregated aggregate with a significant absence of coarse aggregate in the upper on-eight (1/8th) inch of the pavement surface.

b. Shrinkage Cracks. Shrinkage cracks, which do not exceed 4 in in depth, shall be cleaned and then pressure injected with epoxy resin, Type IV, Grade 1, using procedures as approved. Care shall be taken to assure that the crack is not widened during epoxy resin injection. All epoxy resin injection shall take place in the presence of the Engineer. Shrinkage cracks, which exceed 4 in in depth, shall be treated as full depth cracks in accordance with paragraphs 4.19b and 4.19c.

c. Slabs With Cracks through Interior Areas. Interior area is defined as that area more than 6 in (600 mm) from either adjacent original transverse joint. The full slab shall be removed and replaced at no cost to the owner, when there are any full depth cracks, or cracks greater than 4” in depth, that extend into the interior area.

d. Cracks Close To and Parallel To Joints. All cracks essentially parallel to original joints, extending full depth of the slab, and lying wholly within 6 in either side of the joint shall be treated as specified hereinafter. Any crack extending more than 6 in (600 mm) from the joint shall be treated as specified above in subparagraph “Slabs With Cracks Through Interior Area.”

(1) Full Depth Cracks Present, Original Joint Not Opened. When the original uncracked joint has not opened, the crack shall be sawed and sealed, and the original joint filled with epoxy resin as specified below. The crack shall be sawed with equipment specially designed to follow random cracks. The reservoir for joint sealant in the crack shall be formed by sawing to a depth of 3/4 in (19 mm), plus or minus 1/16 in (1.6 mm), and to a width of 5/8 in (16 mm), plus or minus 1/8 in (3.2 mm). Any equipment or procedure which causes raveling or spalling along the crack shall be modified or replaced to prevent such raveling or spalling. The joint sealant shall be a liquid sealant as specified. Installation of joint seal shall be as specified for sealing joints or as directed. If the joint sealant reservoir has been sawed out, the reservoir and as much of the lower saw cut as possible shall be filled with epoxy resin, Type IV, Grade 2, thoroughly tooled into the void using approved procedures.

If only the original narrow saw cut has been made, it shall be cleaned and pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. If filler type material has been used to form a weakened plane in the transverse joint, it shall be completely sawed out and the saw cut pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. Where a parallel crack goes part way across paving lane and then intersects and follows the original joint which is cracked only for the remained of the width, it shall be treated as specified above for a parallel crack, and the cracked original joint shall be prepared and sealed as originally designed.

(2) Full Depth Cracks Present, Original Joint Also Cracked. At a joint, if there is any place in the lane width where a parallel crack and a cracked portion of the original joint overlap, the entire slab containing the crack shall be removed and replaced for the full lane width and length.

e. Removal and Replacement of Full Slabs. Where it is necessary to remove full slabs, unless there are keys or dowels present, all edges of the slab shall be cut full depth with a concrete saw. All saw cuts shall be perpendicular to the slab surface. If keys, dowels, or tie bars are present along any edges, these edges shall be sawed full depth 24 in (150 mm) from the edge if only keys are present, or just beyond the end of the dowels or tie bars if they are present. These joints shall then be carefully sawed on the joint line to within 1 in (25 mm) of the depth of the dowel or key.

The main slab shall be further divided by sawing full depth, at appropriate locations, and each piece lifted out and removed. Suitable equipment shall be used to provide a truly vertical lift, and approved safe lifting devices used for attachment to the slabs. The narrow strips along keyed or doweled edges shall be carefully broken up and removed using light, hand-held jackhammers, 30 lb (14 kg) or less, or other approved similar equipment.

Care shall be taken to prevent damage to the dowels, tie bars, or keys or to concrete to remain in place. The joint face below keys or dowels shall be suitably trimmed so that there is not abrupt offset in any direction greater than 1/2 in (12 mm) and no gradual offset greater than 1 in (25 mm) when tested in a horizontal direction with a 12 ft (3.6 m) straightedge.

No mechanical impact breakers, other than the above hand-held equipment shall be used for any removal of slabs. If underbreak between 1-1/2 and 4 in (37 and 100 mm) deep occurs at any point along any edge, the area shall be repaired as directed before replacing the removed slab. Procedures directed will be similar to those specified for surface spalls, modified as necessary.

If underbreak over 4 in (100 mm) deep occurs, the entire slab containing the underbreak shall be removed and replaced. Where there are no dowels, tie bars, or keys on an edge, or where they have been damaged, dowels of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified. Original damaged dowels or tie bars shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All 4 edges of the new slab shall thus contain dowels or original keys or original tie bars.

Placement of concrete shall be as specified for original construction. Prior to placement of new concrete, the underlying material (unless it is stabilized) shall be re-compacted and shaped as specified in the appropriate SECTION of these specifications. The surfaces of all four joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels or tie bars. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

f. Repairing Spalls Along Joints. Where directed, spalls along joints of new slabs, and along parallel cracks used as replacement joints, shall be repaired by first making a vertical saw cut at least 1 in (25 mm) outside the spalled area and to a depth of at least 2 in (50 mm). Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and at least 1/2 in (12 mm) of visually sound concrete. The cavity thus formed shall be thoroughly cleaned with high-pressure water jets supplemented with compressed air to remove all loose material. Immediately before filling the cavity, a prime coat of epoxy resin, Type III, Grade I, shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Pooling of epoxy resin shall be avoided. The cavity shall be filled with low slump Portland cement concrete or mortar or with epoxy resin concrete or mortar. Concrete shall be used for larger spalls, generally those more than 1/2 cu. ft. (0.014 m3) in size, and mortar shall be used for the smaller ones. Any spall less than 0.1 cu. ft. (0.003 m3) shall be repaired only with epoxy resin mortar or a Grade III epoxy resin. Portland cement concrete and mortar mixtures shall be proportioned as directed and shall be mixed, placed, consolidated, and cured as directed. Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the Engineer. The epoxy resin materials shall be placed in the cavity in layers not over 2 in (50 mm) thick. The time interval between placement of additional layers shall be such that the temperature of the epoxy resin material does not exceed 140 °F (60 °C) at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or mortar. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints, or as required to be routed for cracks. The reservoir shall be thoroughly cleaned and sealed with the sealer specified for the joints. If any spall penetrates half the depth of the slab or more, the entire slab shall be removed and replaced as previously specified. Repair of spalls as described in this section shall not be allowed if in the opinion of the Engineer the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of spalls shall be allowed in any panel that demonstrates segregated aggregate with a significant absence of coarse aggregate in the upper on-eight (1/8th) inch of the pavement surface.

501-4.20 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR.

NOTE: It is imperative that sufficient exploration be made (not just reference to as-built drawings) so that the designer knows exactly what the existing (in place) pavement is at the jointing area-dowels, keys, tie bars, etc. and its condition. Normally the joint between the new pavement and existing pavement should be made at an existing joint in the old pavement.

All operations shall be carefully controlled to prevent damage to the concrete pavement and to the underlying material to remain in place. All saw cuts shall be made perpendicular to the slab surface.

a. Removal of Existing Pavement Slab.

NOTE: Edit bracketed items concerning dowels and keys to conform to the design used. The best results will usually be with a design requiring that keys and dowels be sawed off and new dowels installed in drilled holes. The saw cut at a distance from the joint is always more effective if sawed with a wheel saw-which produces a 1 in (25 mm) kerf and better prevents stress from propagating across the saw cut.

When it is necessary to remove existing concrete pavement and leave adjacent concrete in place, [unless there are dowels or keys present,] the joint between the removal area and adjoining pavement to stay in place, [including dowels, tie bars or keys,] shall first be cut full depth with a standard diamond-type concrete saw. [If keys or dowels are present at this joint, the saw cut shall be made full depth 6 in (150 mm) from the joint if only keys are present, or just beyond the end of dowels if dowels are present. The edge shall then be carefully sawed on the joint line to within 1 in (25 mm) of the top of the dowel or key.] Next, a full depth saw cut shall be made parallel to the joint at least 24 in (600 mm) from the joint and at least 12 in (300 mm) from the end of any dowels. All pavement between this last saw cut and the joint line shall be carefully broken up and removed using hand-held jackhammers, 30 lb. (14 kg) or less, or the approved light-duty equipment which will not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. [Where dowels or keys are present, care shall be taken to produce an even, vertical joint face below the dowels or keys. If the Contractor is unable to produce such a joint face, or if underbreak or other distress occurs, the Contractor shall saw the dowels or keys flush with the joint. The Contractor shall then install new dowels, of the size and spacing used for other similar joints, by epoxy resin bonding them in holes drilled in the joint face as specified in paragraph “Placing dowels and Tie-bars. All this shall be at no additional cost to the Owner.] [Dowels of the size and spacing indicated shall be installed as shown on the drawings by epoxy resin bonding them in holes drilled in the joint face as specified in paragraph “Placing Dowels and Tie Bars”.] The joint face shall be sawed or otherwise trimmed so that there is no abrupt offset in any direction greater than 1/2 in (12 mm) and no gradual offset greater than 1 in (25 mm) when tested in a horizontal direction with a 12 ft. (3.6 m) straightedge.

b. Edge Repair.

NOTE: Edit bracketed items on payment as appropriate.

The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Areas that are damaged during construction shall be repaired at no cost to the Owner; repair of previously existing damage areas [will be paid for as listed in the bid schedule] [will be considered a subsidiary part of concrete pavement construction].

(1) Spall Repair. Spalls shall be repaired where indicated and where directed. Repair materials and procedures shall be as previously specified in subparagraph “Repairing Spalls Along Joints.”

(2) Underbreak Repair. All underbreak shall be repaired. First, all delaminated and loose material shall be carefully removed. Next, the underlying material shall be recompacted, without addition of any new material. Finally, the void shall be completely filled with paving concrete, thoroughly consolidated. Care shall be taken to produce an even joint face from top to bottom. Prior to placing concrete, the underlying material shall be thoroughly moistened. After placement, the exposed surface shall be heavily coated with curing compound.

(3) Underlying Material. The underlying material adjacent to the edge of an under the existing pavement which is to remain in place shall be protected from damage or disturbance during removal operations and until placement of new concrete, and shall be shaped as shown on the drawings or as directed. Sufficient material shall be kept in place outside the joint line to prevent disturbance (or sloughing) of material under the pavement that is to remain in place. Any material under the portion of the concrete pavement to remain in place, which is disturbed or loses its compaction shall be carefully removed and replaced with concrete as specified in paragraph “Underbreak Repair.” The underlying material outside the joint line shall be thoroughly compacted and moist when new concrete is placed.

## MATERIAL ACCEPTANCE

501-5.1 ACCEPTANCE SAMPLING AND TESTING. Acceptance testing and sampling as provided in this section is for the purposes of determining the Contractor’s right to periodic payments for completed work on an interim basis. Acceptance hereunder does not indicate final acceptance and is without prejudice to the right of the Engineer and Sponsor to revoke any previously extended acceptance for any reason set forth herein, including the overall failure of the completed pavement to present a competent and durable pavement placed and resulting in a finished pavement meeting in all respects and regards the highest standards applicable to durable rigid concrete pavements for use in airfield and runway applications. Contractor acknowledges that concrete meeting these material acceptance criteria may not otherwise be acceptable due to conditions such as lack of consolidation, lack of homogeneous quality, lack of density, lack of durability or otherwise and the acceptance criteria in this section are not exclusive as to the final acceptance or quality of the concrete.

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

Testing organizations performing these tests shall meet the requirements of ASTM C 1077. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory’s current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

Concrete shall be accepted for strength and thickness on a lot basis.

The Sponsor (Engineer) shall do the acceptance testing per the standard specifications.

A lot shall consist of:

[ ] cubic yards ([ ] cubic meters).]

[ ] square yards ([ ] square meters).]

[a day’s production not to exceed 2,000 cubic yards (1 530 cubic meters).]

[a day’s production not to exceed [ ] square yards ([ ] square meters).]

The Engineer shall specify the lot size for a project based on the total quantity and the expected production rate. The lot size should not exceed 2,000 cubic yards (1 530 cubic meters). For projects where basis of payment is square yards (square meters), the Engineer shall convert the lot size to an equivalent area that contains 2,000 cubic yards (1 530 cubic meters) or less.

Note: It is recommended that all projects have a testing meeting between the contractor, testing laboratory, and owner’s representative to discuss the sampling and testing of the strength specimens. The meeting should include procedures for sampling fabrication, handling and initial and final curing, and testing of the strength specimens.

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 1/10th in. 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 °F (16 °to 27 °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.

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

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

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

a. Compressive Strength.

(1) Sampling. Each lot shall be divided into four equal sublots. One 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 compressive strength of each specimen shall be determined in accordance with ASTM C 39. The compressive strength for each sublot shall be computed by averaging the results of the two test specimens representing that sublot.

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

b. Pavement Thickness.

(1) Sampling. Each lot 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, that is, 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).

All pavement in its in-place completed condition shall in addition to the foregoing represent concrete pavement of the highest quality and shall be dense and homogenous and of a uniform consistency throughout with non-segregated, evenly distributed aggregate throughout all sections of the pavement. A top surface which is deficient in an even and uniform distribution of coarse aggregate to a depth greater than 1/8ths inch shall not be acceptable and shall cause rejection of any panel in which such condition occurs.

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

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.

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

c. Pavement Thickness. Acceptance of each lot of in-place pavement 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 in

The lower specification tolerance limits above are based on applying statistical analysis to FAA design assumptions, and there is no need to compensate for the above factor in the design process. When the design strength in paragraph 501-3.1 is based on compressive strength, substitute compressive strength for flexural strength and insert 4,140 psi as L for strength.

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 ft (5 m) straightedge or other specified device. Surface smoothness deviations shall not exceed 1/4 in (6 mm) from a 16 ft (5 m) straightedge placed in any direction, including placement along and spanning any pavement joint edge.

Areas in a slab showing high spots of more than 1/4 in (6 mm) but not exceeding 1/2 in (13 mm) in 16 feet (5 m) shall be marked and immediately ground down with an approved grinding machine to an elevation that will fall within the tolerance of 1/4 in (6 mm) or less. Where the departure from correct cross section exceeds 1/2 in (13 mm), the pavement shall be removed and replaced at the expense of the Contractor when so directed by the Engineer. The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130 inches wide. The peaks and ridges shall be approximately 1/32 inch higher than the bottom of the grooves. The pavement shall be left in a clean condition. The removal of all of the slurry resulting from the grinding operation shall be continuous. The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement.

Records shall be maintained showing all smoothness measurements.

Records shall be maintained that show all smoothness and grade measurements. Contracts can be modified to require the contractor to submit the measurements.

Use of the profilograph to measure pavement smoothness is optional and will be approved on a case-by-case basis. Use of a profilometer may not be practical for all construction. However, the profilograph is useful for new construction or overlays designed to correct grade and smoothness deficiencies. If the profilograph is to be included, straightedge requirements need only apply in the transverse direction. To include profilograph requirements delete paragraph (5.2.e.3) and replace with the following:

(3) SMOOTHNESS. As soon as the concrete has hardened sufficiently, the pavement surface shall be tested in the transverse direction with a 16 ft straightedge or other specified device. Surface smoothness deviations shall not exceed 1/4 in from a 16 ft straightedge at any location, including placement along and spanning any pavement joint or edge. The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130 inches wide. The peaks and ridges shall be approximately 1/32 inch higher than the bottom of the grooves. The pavement shall be left in a clean condition. The removal of all of the slurry resulting form the grinding operation shall be continuous. The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement.

Records shall be maintained showing all smoothness measurements.

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

In addition to the 16 ft straight edge, the Contractor shall furnish a 25’ wheel base California type profilograph and competent operator to be used to measure longitudinal pavement surface deviations. The profilograph shall be operated under the supervision of the Engineer and in accordance with the manufacturer’s instructions. The profilograph shall be operated at a speed no greater than a normal walk. Original profilograms for the appropriate locations interpreted in accordance with ASTM E 1274 shall be furnished to the Engineer. The profilograms shall be recorded on a scale of 1 in equal to 25 feet longitudinally and 1 in equal to 1 in or full scale vertically. Records shall be maintained showing all smoothness measurements.

a. The surface of Runway and Taxiway pavements of continuous placement of 50 feet or more shall be tested and evaluated as described herein. Two passes shall be made in each paving lane greater than 20 feet in width; each pass shall be six feet from and parallel with the centerline of the paving lane. The average of the two passes shall be considered as the profilograph result for the paving lane. For paving lanes less than 20 feet in width, one pass along the centerline shall be required. Tests shall be run the next working day following concrete placement. Each trace shall be completely labeled to show paving lane, wheel pass, and stationing.

b. The Contractor shall furnish paving equipment and employ methods that produce a riding surface for each section of pavement having an average profile index meeting the requirements of paragraph 8.1c. A typical subsection will be considered to be the width of the paving lane and 1/10 mile long. The profile index will be determined in accordance with ASTM E 1274 using a 0.2 in blanking band. Within each 1/10th mile subsection, all areas represented by high points having a deviation in excess of 0.4 in in 25 feet or less shall be removed by the contractor using an approved grinding device or a device consisting of multiple diamond blades. The use of a bush hammer or other impact devices will not be permitted. After removing all individual deviations in excess of 0.4 in, additional corrective work shall be performed if necessary to achieve the required ride quality. All corrective work shall be completed prior to determination of pavement thickness.

c. On those pavement subsections where corrections were necessary, second profilograph runs will be performed to verify that the corrections have produced an average profile index of 15 in per mile or less. If the initial average profile index was less than 15, only those areas representing greater than 0.4 in deviation will be re-profiled for correction verification.

d. When the average profile index does not exceed \_\_\_\_\_\_ inches per mile, payment will be made for that section at the contract unit price for the completed pavement. When the average profile index exceeds \_\_\_\_\_\_ inches per mile, but does not exceed 15 in per mile, the Contractor may elect to accept a contract unit price adjustment in lieu of reducing the profile index.

Specify the maximum inches per mile allowed for 100% payment corresponding to the pavement loading conditions as indicate in Paragraph 8.1d.

e. Individual sections shorter than 50 feet and the last 15 feet of any section where the contractor is not responsible for the adjoining section, shall be straightedged in accordance with Section 501.5.2.e.(3).

f. If there is a section of 250 feet or less that has not been independently placed, the profilogram for that section shall be included in the evaluation of the previous section. If there is an individual section of 50 to 250 feet in length, a profilogram shall be made for that section and the pay adjustment factors for short sections of paragraph 8.1c shall apply.

g. Any corrective work required shall be performed prior to joint sealing and grooving operations.

h. All cost necessary to provide the profilograph and related to furnishing the appropriate profilograms as required in this provision are incidental to concrete pavement construction and no direct compensation will be made therefore.

(4) Grade. If there is a section of 250 feet or less that has not been independently placed, the profilogram for that section shall be included in the evaluation of the previous section. If there is an individual section of 50 to 250 feet in length, a profilogram shall be made for that section and the pay adjustment factors for short sections of paragraph 8.1c shall apply.

An evaluation of the surface grade shall be made by the Engineer for compliance to the tolerances contained below. The finish grade will be determined by running levels at intervals of 50 ft (15.2 m) or less longitudinally and all breaks in grade transversely (not to exceed 50 ft) to determine the elevation of the completed pavement. The Contractor shall pay the costs of surveying the level runs, and this work shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the Engineer.

Records shall be maintained that show all smoothness and grade measurements. Contracts can be modified to require the contractor to submit the measurements.

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

Vertical Deviation. Vertical deviation from established grade shall not exceed plus or minus 0.04 ft (12 mm) at any point. Vertical survey shall be conducted on the high point of each joint intersection and compared to the plan elevations to determine the vertical deviation. The finished grade of each lot will be determined by running levels at all joint intersections to determine the elevation of the completed pavement. The Contractor shall pay the cost of surveying and shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the Engineer. When more than 15 percent of all the measurements within a lot are outside the specified tolerance, or if any one shot within the lot deviates ¾ inch or more from planned grade, the Contractor shall remove and replace the deficient slabs to the full width, length and depth of the slab. Patching shall not be permitted. Isolated high points may be ground off provided that the course thickness is not greater than ¼ inch deficient in the design thickness.

(5) Edge Slump. When slip-form paving is used, not more than 15 percent of the total free edge of each 500 ft (150 m) segment of pavement, or fraction thereof, shall have an edge slump exceeding 1/4 in (6 mm), and none of the free edge of the pavement shall have an edge slump exceeding 3/8 in (10 mm). (The total free edge of 500 feet (150 m) of pavement will be considered the cumulative total linear measurement of pavement edge originally constructed as nonadjacent to any existing pavement; that is, 500 feet (150 m) of paving lane originally constructed as a separate lane will have 1,000 feet (300 m) of free edge, 500 feet (150 m) of fill-in lane will have no free edge, etc.). The area affected by the downward movement of the concrete along the pavement edge shall be limited to not more than 18 in (457 mm) from the edge. When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive edge slump shall be removed and replaced at the expense of the Contractor when so directed by the Engineer.

(6) Dowel Bar Alignment. Dowel bars and assemblies shall be checked for position and alignment. The maximum permissible tolerance on dowel bar alignment in each plane, horizontal and vertical, shall not exceed 2 percent or 1/4 in per ft (20 mm per meter) 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 paragraph 501-4.19 of this specification.

g. Final Acceptance and Payment. Final acceptance and payment shall be determined based on a combination of the foregoing factors and such other tests and criteria as shall be necessary to determine before final acceptance and payment that the in-place concrete pavement meets all requirements set forth in this section and the Contract as a whole and represents concrete pavement of the highest quality as required herein. Such additional testing may include but is not limited to petrographic examination conducted pursuant to ASTM C 856. Any one or any combination of the following factors in addition to the acceptance criteria set forth herein shall be sufficient cause for precluding final acceptance and rescission of prior interim acceptance:

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

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

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

## CONTRACTOR QUALITY CONTROL

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

a. Mix Design

b. Aggregate Gradation

c. Quality of Materials

d. Stockpile Management

e. Proportioning

f. Mixing and Transportation

g. Placing and Consolidation

h. Joints

i. Dowel Placement and Alignment

j. Flexural or Compressive Strength

k. Finishing and Curing

l. Surface Smoothness

When the design requires paving an area less than 600 sq yd (500 sq m), the Engineer may request modification to this requirement.

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. If an electronic moisture meter is used, a control chart shall be produced indicating moisture readings and calibration reports entered for the project records.

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. If an electronic moisture meter is used, a control chart shall be produced indicating moisture readings and calibration reports entered for the project records

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. 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.

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 (that is, difference between highest and lowest measurements) for slump and air content in accordance with the following Action and Suspension Limits.

Paragraph 501-6.3 b: Change the table to the following:

|  |  |  |  |
| --- | --- | --- | --- |
| **CONTROL CHART LIMITS** | | | |
| Control Parameter | Individual Measurements | | Range Suspension Limit |
|  | Action Limit | Suspension Limit | (between 2 consecutive tests) |
| Slip Form: | | | |
| Slump | 0 to 1.5 inch (0-38mm) | 0 to 2.0 inch (0-50mm) | 1.5 inch (38 mm) |
| Air Content | +/- 1.2% | +/- 1.8% | +/- 2.5% |
| Side Form | | | |
| Slump | 0.5 to 2.0 inch (13-50mm) | 0 to 3.0 inch (0-75mm) | 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 for the air content.

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 Table 1 and Table 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 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.

## METHOD OF MEASUREMENT

501-7.1 Portland cement concrete pavement shall be measured by the number of [ cubic yards (cubic meters) ] [ square yards (square meters) ] of either plain or reinforced pavement as specified in-place, completed and accepted.

## BASIS OF PAYMENT

501-8.1 PAYMENT. Payment for concrete pavement accepted on an interim basis shall be made at the contract unit price per (square yard) (cubic yard) of either plain or reinforced pavement as specified adjusted in accordance with paragraph 501-8.1a subject to the limitation that:

Such payment is on an interim basis and is subject to reversal in the event final acceptance is not achieved.

Payment for acceptable lots of concrete pavement shall be adjusted in accordance with paragraph 501-8.1a for strength and thickness and 501-8.1c for smoothness, 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 [cubic yards (cubic meters)] [ square yards (square meters)] of concrete pavement used in the accepted work (See Note 1 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 Schedule1

|  |  |
| --- | --- |
| **Percentage of Materials Within Specification Limits (PWL)** | **Lot Pay Factor (Percent of Contract Unit Price)** |
| 96 – 100 | 106 |
| 90 – 95 | PWL + 10 |
| 75 – 90 | 0.5 PWL + 55 |
| 55 – 74 | 1.4 PWL – 12 |
| Below 55 | Reject2 |

1Although 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.

2The 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.

Payment shall be made under:

Item P-501-8.1a Portland Cement Concrete Pavement – [per cubic yard (cubic meter)] [per square yard (square meter)]

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **(Average Profile Index (Inches Per Mile)**  **Pavement Strength Rating** | | | **Contract Unit Price Adjustment**  **(PFm)** | | |
| Over 30,000 lb | | 30,000 lb or Less | | 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 and up | 15.1 and up | | 22.1 and up | | Corrective work required |

## 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 C 1567 | Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Cementitious Materials and Aggregates (Accelerated 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 Flyash 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 Structural Construction (Non-extruding 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 |
| Department of Defense MIL-DTL-24441/20a | (1999)\_Paint, Epoxy-Polyamide, Green Primer, Formula 150, Type III |

End of Item P-501

## REFERENCES

1. AASHTO M 254 plastic or epoxy-coated steel dowels
2. AASHTO M 254 Specification for Coated Dowel Bars
3. AASHTO T 26 water
4. AASHTO T 26 Quality of Water to be Used in Concrete
5. ACI 306R Cold Weather Concreting
6. ACI 305R Hot Weather Concreting
7. ASTM cement
8. ASTM reinforcing steel
9. ASTM steel reinforcement
10. ASTM test(s) for each material
11. ASTM A 184 bar mats
12. ASTM A 184 Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
13. ASTM A 185 welded steel wire fabric
14. ASTM A 185 Specification for Welded Steel Wire Fabric for Concrete Reinforcement
15. ASTM A 497 welded deformed steel fabric
16. ASTM A 497 Specification for Welded Deformed Steel Wire Fabric for Concrete Pavement
17. ASTM A 615 tie bars
18. ASTM A 615 dowel bars
19. ASTM A 615 Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
20. ASTM A 616 Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement
21. ASTM A 617 Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement
22. ASTM A 704 bar mats
23. ASTM A 704 Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
24. ASTM A 714 high strength dowel bars
25. ASTM A 714 Specification for High-Strength Low-Alloy Welded and Seamless Steel Pipe
26. ASTM C 31 flexural strength test specimens preparation
27. ASTM C 31 test specimens molded and cured
28. ASTM C 31 testing specimens
29. ASTM C 31 Making and Curing Concrete Test Specimens in the Field
30. See ASTM C 33 potential reactivity
31. ASTM C 33 fine aggregate
32. ASTM C 33 gradation fine aggregate
33. ASTM C 33 coarse aggregate
34. ASTM C 33 deleterious substances
35. ASTM C 33 class
36. ASTM C 33 coarse aggregate gradation
37. ASTM C 33 deleterious activity
38. ASTM C 33 Specification for Concrete Aggregates
39. ASTM C 39 compressive strength testing
40. ASTM C 39 Compressive Strength of Cylindrical Concrete Specimens
41. ASTM C 70 moisture content fine aggregate
42. ASTM C 70 Surface Moisture in Fine Aggregate
43. ASTM C 78 flexural strength test specimens testing
44. ASTM C 78 flexural strength
45. ASTM C 78 Test for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
46. ASTM C 94 batch plant and equipment
47. ASTM C 94 central plant mixer
48. ASTM C 94 truck mixers and truck agitators
49. ASTM C 94 non-agitator trucks
50. ASTM C 94 concrete mixed and delivered
51. ASTM C 94 Specification for Ready-Mixed Concrete
52. ASTM C 131 percentage of wear
53. ASTM C 131 Test for Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
54. ASTM C 136 fine aggregate gradation
55. ASTM C 136 coarse aggregate gradation
56. ASTM C 136 gradation sieve analysis fine aggregate
57. ASTM C 136 gradation sieve analysis coarse aggregate
58. ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates
59. ASTM C 138 unit weight and yield tests
60. ASTM C 138 Test for Unit Weight, Yield and Air Content (Gravimetric) of Concrete
61. ASTM C 143 slump
62. ASTM C 143 slump tests
63. ASTM C 143 Test for Slump of Portland Cement Concrete
64. ASTM C 150 cement
65. ASTM C 150 portland cements
66. ASTM C 150 Specification for Portland Cement
67. ASTM C 171 white polyethylene film for curing concrete
68. ASTM C 171 white burlap-polyethylene sheeting for curing concrete
69. ASTM C 171 waterproof paper for curing concrete
70. ASTM C 171 Specification for Sheet Materials for Curing Concrete
71. ASTM C 172 concrete sampling
72. ASTM C 172 Sampling Freshly Mixed Concrete
73. ASTM C 173 air content slag and other highly porous, coarse aggregate
74. ASTM C 173 air content tests for slag or other porous coarse aggregate
75. ASTM C 173 Test for Air Content of Freshly Mixed Concrete by the Volumetric Method
76. ASTM C 174 thickness of the cores
77. ASTM C 174 Measuring Length of Drilled Concrete Cores
78. ASTM C 227 reactivity tests
79. ASTM C 227 mortar-bar expansion test
80. ASTM C 227 mortar bar method
81. ASTM C 227
82. ASTM C 227 Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
83. ASTM C 231 air content gravel and stone coarse aggregate
84. ASTM C 231 air content tests for gravel and stone coarse aggregate
85. ASTM C 231 Test for Air Content of Freshly Mixed Concrete by the Pressure Method
86. ASTM C 260 air-entraining admixtures
87. ASTM C 260 Specification for Air-Entraining Admixtures for Concrete
88. ASTM C 289 reactivity tests
89. ASTM C 289 quick chemical test
90. ASTM C 289 chemical test
91. ASTM C 289 test results
92. ASTM C 289 Potential Reactivity of Aggregates (Chemical Method)
93. ASTM C 295 reactive minerals
94. ASTM C 295 petrographic examination
95. ASTM C 295 Petrographic Examination of Aggregates for Concrete
96. ASTM C 309 liquid membrane-forming compounds for curing concrete
97. ASTM C 309 Specification for Liquid Membrane-Forming Compounds
98. ASTM C 311 Sampling and Testing Fly Ash for Use as an Admixture in Portland Cement Concrete
99. ASTM C 494 chemical admixtures
100. ASTM C 494 water-reducing, set-controlling and other approved admixtures tests
101. ASTM C 494 Specification for Chemical Admixtures for Concrete
102. ASTM C 535 percentage of wear
103. ASTM C 535 Test for Resistance to Abrasion of Large Size Coarse Aggregate by Use of the Los Angeles Machine
104. ASTM C 566 moisture content fine aggregate
105. ASTM C 566 moisture content coarse aggregate
106. ASTM C 566 Total Moisture Content of Aggregates by Drying
107. ASTM C 595 cement
108. ASTM C 595 blended hydraulic cements
109. ASTM C 595 Specification for Blended Hydraulic Cements
110. ASTM C 618 fly ash
111. ASTM C 618 Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
112. ASTM C 666 Resistance of Concrete to Rapid Freezing and Thawing
113. ASTM C 666 aggregate testing
114. ASTM C 881 epoxy-resin
115. ASTM C 881 Specification for Epoxy-Resin-Base Bonding System for Concrete
116. ASTM C 989 ground blast furnace slag
117. ASTM C 989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
118. ASTM C 1077 reactivity testing laboratory
119. ASTM C 1077 testing laboratory including accreditation
120. ASTM C 1077 testing organizations including accreditation
121. ASTM C 1077 Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
122. ASTM D 1751 premolded joint filler expansion joints
123. ASTM D 1751 joint filler
124. ASTM D 1751 Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)
125. ASTM D 1752 premolded joint filler expansion joints
126. ASTM D 1752 joint filler
127. ASTM D 1752 Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
128. ASTM D 3665 random sampling procedures
129. ASTM D 3665 Random Sampling of Construction Materials
130. ASTM D 4791 flat or elongated pieces
131. ASTM D 4791 Test Method for Flat or Elongated Particles in Coarse Aggregate
132. ASTM P 214 Accelerated Detection of Potentially Deleterious Expansion of Mortar Bars Due to Alkali-Silica Reaction
133. EPA guidelines fly ash
134. FAA Item P-501 Portland Cement Concrete Pavement
135. Federal Specification TT-P-664 high strength dowel bars paint
136. TT-P-644 Federal Specification for Primer Coating, Alkyd, Corrosion Inhibiting, (Rev. D) Lead and Chromate Free, VOC-Compliant
137. 40 CFR Part 249 fly ash
138. Portland Cement Association’s manual “Design and Control of Concrete Mixtures” mix design

End of Item