An *IPRF* Research Report

Innovative Pavement Research Foundation

Airport Concrete Pavement Technology Program

Report IPRF-01-G-002-04-1

A Proposed Specification for Construction of Concrete Airfield Pavement

Programs Management Office
5420 Old Orchard Road
Skokie, IL 60077

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A Proposed Specification for Construction of Concrete Airfield Pavement

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PREFACE

This report has been prepared by the Innovative Pavement Research Foundation (IPRF) under the Airport Concrete Pavement Technology Program. Funding is provided by the Federal Aviation Administration (FAA) under Cooperative Agreement Number 01-G-002-04-1. Dr. Satish Agrawal is the Manager of the FAA Airport Technology R&D Branch and the Technical Manager of the Cooperative Agreement. Mr. Jim Lafrenz is the IPRF Cooperative Agreement Program Manager.

The IPRF and the FAA thank the Technical Panel that willingly gave of their expertise and time for the development of this report. They were responsible for the oversight and the technical direction. The names of those individuals on the Technical Panel follow.

David Cross, National Association of State Aviation Officials
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The project team would like to acknowledge the contributions by the staff of the following:

- Federal Aviation Administration
- Transportation Systems Center, U.S. Army Corps of Engineers

The project team would also like to acknowledge that the proposed specification incorporates the collective experience of a broad range of experts who have, over the years, contributed so much to the developments in airport concrete pavement construction technology. As a result of their contributions, which have produced long lasting concrete pavements, the United States enjoys one of the best aviation systems in the world.

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented. The contents do not necessarily reflect the official views and policies of the Federal Aviation Administration. This report does not constitute a standard, specification, or regulation.

EXECUTIVE SUMMARY

The Standards for Specifying Construction of Airports, FAA Advisory Circular: AC 150/5370-10B incorporates Item P-501 – Portland Cement Concrete Pavement. Airport concrete pavement project funded under the federal airport improvement program (AIP) are typically developed in accordance with the requirements contained in Item P-501 and sometimes in conjunction with specific project requirements and local practices related to material availability and regional concerns, and as approved by the FAA.

The current version of Item P-501, released in 1989 and since modified several times, provides guidance on the following:

1. Concrete materials (including composition and materials requirements)
2. Construction methods (including equipment, concrete placement, finishing, jointing, curing, and sealing)
3. Method of acceptance (including sampling and testing)
4. Contractor quality control
5. Basis for payment

Since the early 1990's, significant changes have taken place in concrete technology as well as concrete pavement construction technology. Although Item P-501 has been modified several times, many of the changes and new concepts have not been formally incorporated in the specification. As part of a recent IPRF study, a proposed specification for concrete airfield pavement has been developed for possible adoption by the FAA.

The proposed specification places emphasis on the need to produce a durable end product, that is, a durable concrete pavement. The product requirements that are specified are a combination of prescriptive requirements for certain materials as well as end product requirements for the as-delivered concrete and for the as-placed concrete. There is less emphasis on the means and methods to produce the end product. This should allow the contractor reasonable flexibility to use innovative construction methods and equipment that will result in cost savings to owner agencies without sacrificing the quality of the product.

Specifically, the proposed specification will allow constructors to identify sources of variability in the airfield concrete pavement construction process and to minimize the variability; thus delivering an end product that is consistent and durable. The proposed specification intent is to:

1. Inspire creativity and maintain a standard for the evaluation of the construction
2. Incorporate a system of measurement consistent with acceptance criteria that will validate the design parameters
3. Encourage innovation and be "results-oriented"
4. Result in a product of the highest quality and consistent with the available local materials.

The key items of the proposed specification are listed below:

1. Emphasis on end product requirements for the concrete and the concrete pavement.

2. Denoting aggregates as a generic material and not as coarse and fine aggregates.
3. Requirement to optimize the combined aggregate gradation which results in a dense concrete matrix that has the attributes needed for workability and long-term durability.
4. Requirement of a plan for mitigation of reactive aggregates.
5. Allowing use of splitting tensile strength testing for concrete strength acceptance.
6. No prescriptive requirements of paving equipment.
7. Construction of a test section to demonstrate and validate the Contractor’s concrete production and concrete placement processes.
8. Requiring a Weather Management Plan, as applicable, for larger projects.
9. Contractor’s process control testing to include the following new requirements:
    a. Combined aggregate gradation
    b. Limit on hand finishing at edges
10. Concrete strength and pavement thickness acceptance testing to be performed by the contractor. The Engineer observes the contractor’s testing and performs other required acceptance testing.
11. A pavement construction lot to include five sublots. This provides for improved statistical evaluation of the end product requirements.
12. The number of strength specimens to be tested per lot is three when the splitting tensile strength testing option is used. This provides for improved statistical sampling of the concrete.
13. Graduated requirements for projects requiring less than 10,000 cubic yards of concrete placement.

A Supplemental Report for the proposed specification has also been prepared to provide explanatory notes and guidance on key specification items incorporated in the proposed specification and to clarify the intent of the specification. The Supplemental Report also discusses the impacts of deviations from specifications and provides guidance on recommended practices. The report is available from the Innovative Pavement Research Foundation.

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PROPOSED SPECIFICATION FOR CONCRETE AIRFIELD PAVEMENT

1.0 DESCRIPTION

1.1 General

This work shall consist of pavement composed of hydraulic cement concrete, constructed on a prepared underlying surface, in accordance with these specifications and shall conform to the lines, grades, thickness, and typical cross sections shown on the plans.

1.2 End Product

The end product for the work is the concrete pavement constructed using materials, equipment and processes specified in this specification. The end product shall be accepted or shall be considered deficient or defective on the basis of the following acceptance testing:

1. Surface smoothness. See Para. 9.3.1 – Straightedge
2. Vertical grade. See Para. 9.3.2 – Vertical Grade
~~3.~~ Edge slump. See Para. 9.3.3 – Edge Slump
~~4.~~ Dowel Bar Alignment. See Para. 9.3.4 - Dowel Bar Alignment
5. Cracking. See Para. 9.3.5 – Cracking
6. Sliver Spalls. See Para. 9.3.6 - Sliver Spalls
7. Joint Spalls. See Para. 9.3.7 - Joint Spalls
8. Slab thickness. See Para. 9.4.1 – Thickness
9. Flexural strength. See Para. 9.4.2 – Strength.

Deficient pavement areas shall be mitigated as per Para. 10.1 - Deficient Pavement. Defective pavement areas shall be mitigated as per Para. 10.2 - Defective Pavement.

1.3 End Product Responsibility

The Contractor is entirely responsible for the materials and processes that produce the end products specified in this specification. It is the Contractor's responsibility to prove by means of a test section, constructed at the start of construction, that the process for constructing the concrete pavement is valid.

The Engineer will determine if the Contractor's materials and processes produce an end product that is in conformity with the plans and specifications. Tolerances to determine conformity for measurable components of the materials, processes, and end product are provided.

When the Engineer determines that the materials furnished, work performed, or the finished product are not in conformity with the plans and specifications and result in an unacceptable product, the affected work or materials shall be removed and replaced or otherwise corrected at the Contractor's expense in accordance with Para. 10.0 – Deficient and Defective Pavement.

1.4 Pre-Paving Conference

At least 7 days before and not more than 30 days before concrete placement, the Contractor and his team members shall attend a pre-paving conference with the Engineer and airport personnel to review project specific requirements related to the concrete paving and related project-planning activities. The following are the minimum agenda items:

1. Submittals and status of submittals.
2. Critical material supply/availability issues.
3. Concrete plant and aggregate stockpile management.
4. Concrete paving requirements.
5. Paving schedule.
6. Weather management plan.
7. Test section requirements.
8. Contractor process testing.
9. Contractor acceptance testing requirements.
10. Engineer monitoring of acceptance testing.
11. Who on Contractor's staff has stop work authority?
12. Who on Owner's staff has stop work authority?
13. Issues and disputes resolution hierarchy.

****
Graduated Requirements

All works generally requiring less than about 10,000 cubic yards of concrete placement are designated as small projects. This specification is not applicable to works generally requiring less than about 2,000 cubic yards. The specification options, as applicable, shall be selected to reflect project size.
****

2.0 SUBMITTALS

The Contractor shall provide the submittals listed in the following sections. The personnel and laboratories conducting the aggregate and concrete related testing for the project shall meet the requirements of Para. 8.1 – Testing Personnel and Para. 8.2 – Testing Laboratory Requirements, respectively.

2.1 Pre-construction Submittals

Pre-construction submittals shall be submitted to the Engineer before the pre-paving meeting. Submittals include, but are not limited to, the following:

1. Qualifications of the plant inspector, when applicable.
2. Concrete plant checklist as per the National Ready Mix Concrete Association (NRMCA) QC3 (Plant Certification Check List) process.

3. Concrete testing laboratory certification.
4. Contractor testing personnel certification.
5. Cement mill certificates.
6. Supplementary cementing material mill certificates.
7. Aggregate certification.
8. Admixture certification.
9. Water certification.
10. Expansion board certification.
11. Embedded steel certification.
12. Tie bar steel certification.
13. Dowel bar coating certification.
14. Dowel anchoring mortar certification.
15. Curing material certification.
16. For each concrete mixture to be used:
    a. Maximum aggregate size and target air content
    b. Combined aggregate gradation.
    c. Concrete mixture proportions.
    d. Flexural versus splitting tensile strength correlation data, when applicable.
17. Concrete uniformity test results.
18. Weather management plan.
19. Contractor quality control/acceptance testing program.

For aggregate and concrete mixtures to be used on the project, the pre-construction certifications shall be developed using materials sampled not more than 180 days before the start of concrete placement. The certification for the reactive aggregate mitigation plan shall be for aggregates sampled not more than 90 days before the start of concrete placement.

For cement and supplementary cementing materials, mill certification for each truckload of the material shall be submitted to the Engineer within 24 hours of material delivery.

2.1 Process Control Testing Submittals

Submittals related to process control testing include the results of the Contractor's process control testing, as per Para. 8.0 – Process Control. The Engineer shall be notified of the results in writing within 72 hours of completion of a day's paving. These submittals include the following process control tests:

1. Accuracy of plant batching.
2. Aggregate quality.
3. Combined aggregate gradation – Workability and Coarseness Factors.
4. Air content, when applicable.
5. Concrete temperature.

2.3 Contractor Acceptance Testing Submittals

Submittals related to Contractor acceptance testing include the results of the Contractor performed acceptance testing for pavement thickness and concrete flexural strength, as per Para. 9.4 – Contractor Performed Acceptance Tests. The Engineer shall be notified of the results in writing within 72 hours of pavement thickness being measured and within 72 hours of concrete strength being determined for a lot.

3.0 MATERIALS

The materials to be used in the construction of the concrete pavement shall meet the requirements of this paragraph. New submittals are required when the material source or type changes.

3.1 Cementitious Materials

Cementitious materials shall include hydraulic cement and supplementary cementitious materials.

3.1.1 Hydraulic Cement

Hydraulic cement shall conform to the requirements of ASTM C 150, Type I or II **[ ]** or ASTM C595, Type **[ ]** or ASTM C 1157, Type **[ ]**.

** ***********
ASTM C 150 covers portland cements Type I, II, III, and V. Type I and II are the most common. ASTM C 150, Type III is a high-early-strength cement and its use shall be limited to fast-track paving applications. Type V is used in concrete exposed to severe sulfate action.

ASTM C 595 covers blended hydraulic cements as follows: Type IP(XX) - Portland-Pozzolan Cement and Type IS(XX) - Portland Blast-Furnace Slag Cements. The XX in parenthesis denotes the allowable maximum percent of pozzolan or slag in the blended cement.

ASTM C 1157 is a performance-based classification for hydraulic cement. These cements are defined by their performance attributes and must meet physical performance test requirements, as opposed to prescriptive restrictions on ingredients or cement chemistry as found in other cement specifications. The specification covers the following cements: Type GU (for general use including paving applications), Type HE (for high early strength), Type MS (for moderate sulfate resistance), Type HS (for high sulfate resistance), Type MH (for moderate heat of hydration), and Type LH (for low heat of hydration).
****

3.1.2 Supplementary Cementitious Materials

Supplementary cementitious materials (SCMs) may be used as part of the total cementitious content.

3.1.2.1 Fly Ash

Fly ash shall meet the requirements of ASTM C 618 for Class C or F. **[The supplementary optional physical requirements, except the ones pertaining to alkali-silica reactivity, contained in ASTM C 618 shall apply.] [The supplementary optional physical requirements, except the ones pertaining to alkali-silica reactivity and sulfate resistance, contained in ASTM C 618 shall apply.]**

****

Delete the first option if sulfate resistant concrete is not required. Delete the second option if sulfate resistant concrete is required.

****

3.1.2.2 Ground Granulated Blast Furnace Slag (GGBFS)

Ground granulated blast furnace slag shall meet the requirements of ASTM C 989, Grade 100 or Grade 120.

3.1.2.3 Other SCMs

Other SCMs, when used, shall meet the requirements of applicable ASTM standards.

3.2 Aggregates

Sources of aggregates shall be selected by the Contractor. There is no limit to the number of aggregate sizes that may be used or blended. **[Maximum aggregate size shall be selected by the Contractor.] [Maximum aggregate size shall be [ ] inch.]**

****

In regions with D-Cracking, the Engineer may specify a ¾-inch maximum aggregate size. However, specifying a maximum aggregate size of ¾ inch may reduce, but not eliminate, D-Cracking distress development. The maximum aggregate size for D-cracking also needs to be coordinated with Item 8, Para. 3.2.2 – Aggregate Quality, as State DOTs may specify the maximum aggregate size separately for D-cracking, e.g. by ledge. The Engineer needs to evaluate this requirement based upon experience in the region. Some airports have strict requirements on airfield paving, and may have an airport-required maximum aggregate size and/or specified gradation, in which case modify the requirements accordingly.

****

3.2.1 Gradation Evaluation of the Proposed Aggregates

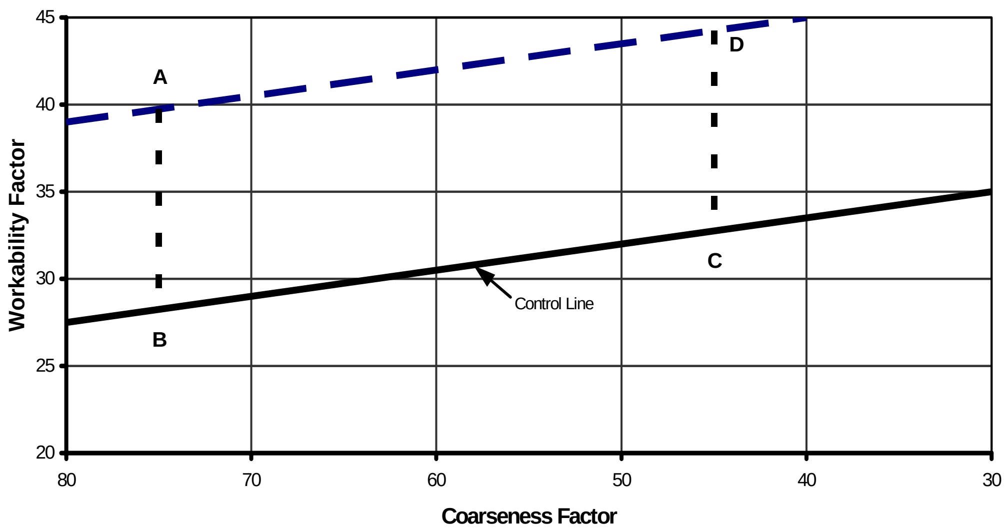
The Contractor shall combine the aggregates in the proportions proposed for the concrete mixture and evaluate on the following sieve sizes: 2½-inch, 2-inch, 1½-inch, 1-inch, ¾-inc., ½-inch, ⅜-inch, No. 4, No. 16, No. 30, No. 50, and No. 100.

The Contractor shall determine the Workability Factor (WF) and the Coarseness Factor (CF). The WF is the percentage of the combined aggregate by weight finer than the No. 8 sieve. The CF is the percent of material by weight retained on the ⅜-inch sieve divided by the percent by weight of all the aggregate retained on the No. 8 sieve and multiplying the ratio by 100.

The aggregates, as proportioned, shall be deemed to have met the requirements of a combined aggregate gradation when the following criterion is met:

- The WF and CF shall be within the parallelogram ABCD of the Aggregate Constructability Chart (Figure 1).

.
The combined aggregates, as proportioned, shall be rejected if the combined aggregate gradation criterion is not met.



Point A – CF = 75; WF = 40; Point B – CF = 75; WF = 28
Point C – CF = 45; WF = 32; Point D – CF = 45; WF = 44

Figure 1 – Aggregate Constructability Chart

3.2.2 Aggregate Quality

The aggregates shall meet the following requirements:

1. The portion of the combined aggregate passing the No. 4 sieve shall meet the requirements for deleterious substances contained in ASTM C 33, Table 1.

2. The portion of the combined aggregate retained on the No. 4 sieve shall meet the requirements for deleterious substances contained in ASTM C 33, Table 3, Class **[ ]** for pavements.

****
Class 4S shall be specified for severe weathering regions, 4M for moderate weathering regions and 1N for negligible weathering regions. Engineer may specify the military requirements for aggregates if military aircraft will use the pavement facility or if foreign object damage (FOD) from causes other than ASR, D-Cracking, or joint and crack spalling has been a problem at the airport facility. Engineer will determine if there are historic aggregate problems in the region by observation of older pavements at the airport and surrounding areas and by review of material requirements in State DOT concrete pavement construction specifications. The stricter requirements of the State DOT or ASTM C 33 shall be used. Military requirements may also be used to resolve specific aggregate problems. The Engineer's review shall be documented in the Engineer's Basis of Design report.
****

3. Soundness testing in accordance with ASTM C 88 for each aggregate or for the combined aggregate in the proportion to be used for the concrete mixture shall not show more than 18 percent loss when subjected to 5 cycles using magnesium sulfate. When sodium sulfate is used, results shall not show more than 12 percent loss when subjected to 5 cycles.

4. The portion of combined aggregate retained on the No. 4 sieve shall not contain more than 20 percent by weight of flat or elongated pieces when tested in accordance with ASTM D 4791. A flat particle is defined as one having a ratio of width to thickness greater than 3 and an elongated particle is one having a ratio of length to width greater than 3.

5. For the portion of the combined aggregate retained on the No. 4 sieve, the percentage of wear shall be no more than **[40] [ ]** at 500 revolutions when tested in accordance with ASTM C 131 or ASTM C 535.

****
The Engineer may specify a maximum percentage wear of 50 in regions when local availability of harder aggregates is poor.
****

6. Use of steel-making slag as an aggregate is not permitted.

7. **[Not Used] [Aggregates that have a history of D-cracking shall not be used.] [Aggregates meeting _______________ Department of Transportation Class _________ shall be used.] [Aggregate shall have a Durability Factor of 95 or more when subjected to freezing and thawing in accordance with ASTM C 666, Procedure A, using an air-entrained concrete mixture with a water-cementitious-**

materials ratio of 0.40 to 0.45. The test data shall not be more than one year old at the time of submittal.]

****

Engineer will determine if D-cracking related requirements are necessary based on local experience. Typically, the State DOT will have already identified D-Cracking issues, and the Engineer will insert the State DOT provisions for appropriate approved aggregate sources. Note that the State DOT requirements for D-cracking may be different than for maximum aggregate size. Therefore, this item should be coordinated with Para. 3.2 - Aggregates. Explicitly include the requirements for adjacent states if it is probable that sources from these states may be imported for the project. Engineer is cautioned to carefully refer to the applicable State DOT specifications related to D-cracking to ensure that these requirements will not conflict with other coarse aggregate requirements in this specification. Do not make a blanket reference to DOT standards; carefully select and cite the appropriate Para. and sections; and ensure non-applicable references in the DOT manual to other DOT requirements are stricken.

If the Contractor uses an out-of-state aggregate source and the State from where the aggregates are originating from does not have D-cracking related requirements that equal or exceed the requirements of the local State DOT, the Engineer will require the conduct of ASTM C 666 testing, knowing that a lead time of about 4 months will be necessary to conduct the ASTM C 666 testing. The Durability Factor shall be greater than or equal to 95 (Method A).

****

8. **[Not used] [Recycled crushed concrete for aggregate shall be from a known source. Recycled aggregates shall meet all of the requirements applicable to virgin aggregates, except for the requirements related to ASTM C 131 or ASTM C 535 tests.]**

****

Use of recycled concrete is cautioned. When specified, recycled concrete aggregate needs to be from a known source. The Engineer will have petrographic testing conducted, especially for Alkali-Silica Reactivity (ASR) and Durability Cracking (D-Cracking) before identifying such concrete for recycled aggregate in the project documents, and do not use when these or other detrimental properties are present. Do not allow recycled crushed concrete from a commercial recycle yard.

****

9. **[Not used.] [Historical test results for Items 1-5 [and 7] above can be submitted, at Contractor's option, when all of the aggregate for the project can be produced from the same ledge within 180 days of sampling for the testing.]**

****

Historical records are acceptable for small projects.

****

3.2.3 [Not Used] [Aggregate Reactivity

3.2.3.1 Reactive Aggregate Screening

The Contractor shall determine if the aggregates are deleteriously reactive with alkalis in accordance with ASTM C 1260 (or ASTM C 1567 when SCMs are used). The aggregate used for the coarse fraction and the aggregate used for the fine fraction shall be evaluated independently. Test results that have a measured expansion equal to or greater than 0.10% at 16 days from casting indicates an aggregate that is reactive. The results of testing shall be submitted to the Engineer.

Aggregates determined to be reactive shall be rejected or the Contractor shall develop an alkali-silica reactivity (ASR) mitigation plan in accordance with Para. 3.2.3.2 – ASR Mitigation.

3.2.3.2 ASR Mitigation

When the aggregates are determined to be reactive, the Contractor shall establish the reactive aggregate mitigation plan. The mitigation plan may include testing a combination of proportioned materials and/or incorporating SCMs, lithium nitrate, or combinations thereof. The mitigated concrete mixture shall not exhibit expansion in excess of 0.08% at 16 days from casting when tested in accordance with ASTM C 1567.

When lithium nitrate is selected for mitigation, the nominal dosage shall be that required to maintain 0.74 molar ratio. The actual dosage of lithium nitrate shall be based on the total alkali load.

The results of testing shall be submitted to the Engineer.]

3.2.4 [Not Used] [Aggregate Reactivity – Deicer Use Airports

3.2.4.1 Reactive Aggregate Screening

The Contractor shall determine if the aggregates are deleteriously reactive with alkalis in accordance with ASTM C 1260. The Contractor shall not use ASTM C 1567 for aggregate screening. The aggregate used for the coarse fraction and the aggregate used for the fine fraction shall be evaluated independently as required by ASTM C 1260. Test results that have a measured expansion equal to or greater than 0.10% at 30 days from casting indicates an aggregate that is reactive. The results of testing shall be submitted to the Engineer.

3.2.4.2 Reactive Aggregate Screening with Deicer Soak Solution

The Contractor shall determine if the aggregates are deleteriously reactive with alkalis in accordance with ASTM C 1260, using a 50% potassium acetate soak solution. The

aggregate used for the coarse fraction and the aggregate used for the fine fraction shall be evaluated independently as required by ASTM C 1260. Test results that have a measured expansion equal to or greater than 0.10% at 30 days from casting indicates an aggregate that is reactive. The results of testing shall be submitted to the Engineer.

3.2.4.3 Reactive Aggregate Mitigation

When testing as per Para. 3.2.4.1 - Reactive Aggregate Screening or Para. 3.2.4.2 - Reactive Aggregate Screening with Deicer Soak Solution indicates that the aggregates are reactive, the Contractor shall establish the reactive aggregate mitigation plan. The mitigation plan may include testing a combination of proportioned materials and/or incorporating SCMs, lithium nitrate, or combinations thereof.

The mitigated concrete mixture, using the combined concrete materials in the proportions to be used, shall be tested using both of the procedures outlined in Para. 3.2.4.1 - Reactive Aggregate Screening and Para. 3.2.4.2 - Reactive Aggregate Screening with Deicer Soak Solution. The test samples shall not exhibit expansion in excess of the limits prescribed in the two procedures.

When lithium nitrate is selected for mitigation, the nominal dosage shall be that required to maintain 0.74 molar ratio. The actual dosage of lithium nitrate shall be based on the total alkali load.

The results of testing shall be submitted to the Engineer.]

****

The Engineer will determine if the airport pavement is subject to deicer use. Delete Para. 3.2.3 when the airport pavements are to be subjected to deicer use. Delete Para. 3.2.4 when the airport pavements are not to be subject to deicer use.

The Engineer will consider the time requirement for the reactive aggregate testing when the project is advertised and when it is let to allow the Contractors adequate time to perform the necessary reactive aggregate testing.

****

3.3 Water

Water shall meet the requirements of ASTM C 1602. Water known to be potable may be used without testing.

3.4 Chemical Admixtures

Chemical admixtures may only be used when the specific admixture type and manufacturer is the same material used in the mixture proportions approved by the Engineer. Calcium chloride, admixtures containing calcium chloride **[and]** shall not be used.

****
The Engineer may insert the names or types of admixtures to be excluded, based on local experience and Airport requirements.
****

3.4.1 Air-Entraining Admixture

The air-entraining admixture shall meet the requirements of ASTM C 260.

3.4.2 Water Reducing, Set Retarding, and Accelerating Admixture

Retarding, water-reducing, and accelerating admixtures shall meet the requirements of ASTM C 494/C 494M, Type A, B, C, D, or E.

3.4.3 Other Admixtures

The Contractor may use other admixtures, provided these admixtures are used in accordance with the manufacturer's recommendations or industry standards.

3.5 Forms

Forms shall have a depth equal to the pavement thickness at the edge. Forms shall be cleaned each time before concrete is placed.

3.6 Expansion Board

The expansion board for expansion and isolation joints shall conform to the requirements of **[ASTM D 1751] [ASTM D 1752, Type II or III]**. When dowels are used at expansion joints, holes shall be precut in the expansion board. Expansion board shall be fitted with a removable cap with the proper dimensions for the joint-seal reservoir shown on the plans. The filler for each joint shall be furnished in a single piece for the full depth required for the joint.

3.7 Embedded Steel

Embedded steel shall **[conform to the requirements of ASTM [A 185] [A 497] [A 184 or A 704] [A 615] [, Grade 60] [meet the requirements as shown on the plans]. [Welded wire fabric shall be furnished in flat sheets only.]**

****
The Engineer will designate the appropriate steel for the project:

Welded steel wire fabric	**ASTM A 185**
Welded deformed steel fabric	**ASTM A 497**
Bar mats	**ASTM A 184 or A 704**
Deformed bars	**ASTM A 615**

Grade 60 steel is the most common used. Welded wire fabric shall be furnished in flat sheets only.
****

3.8 Tie Bars

Tie bars shall be deformed steel bars and conform to the requirements of ASTM A 615, Grade 60 or Grade 40. Grade 60 tie bars shall not be bent or re-straightened during construction. Tie bars designated as Grade 40 in ASTM A 615 shall be used for construction requiring bent bars.

[Before delivery to the construction site, tie bars shall be coated on all surfaces lengthwise with epoxy coating conforming to the requirements of ASTM A 775/A 775M, with a minimum thickness of 8 mils.]

****
Epoxy coating of tie bars is not necessary for airfield concrete pavements because deicing salts are not used at airfield pavements. However, in coastal environments, the Engineer may require use of epoxy coating to mitigate steel corrosion.
****

3.9 Dowel Bars

Dowel bars shall be smooth steel bars conforming to ASTM A 615, Grade 60 and shall be free of loose material, be clean and straight. Dowel bar deviation from true shape shall not exceed 0.04 inch on the diameter of the dowel and shall not extend more than 0.04 inch from the end of the dowel.

3.9.1 Dowel Bar Corrosion Protection Coating

Before delivery to the construction site, steel dowel bars shall be coated on all surfaces lengthwise with **[one coat of paint conforming to the requirements of Military Specification MIL-DTL-24441/20A, [SSPC Paint 5] [, or] [SSPC Paint 25] [one coat of paint conforming to the requirements of Federal Specification TT-P-664] [epoxy coating conforming to the requirements of ASTM A 775/A 775M, with a minimum thickness of 8 mils].**

****
Epoxy coating of dowel bars is not necessary for airfield concrete pavements because deicing salts are not used at airfield pavements. However, in coastal environments, the Engineer may require use of epoxy coating to mitigate steel corrosion.
****

3.9.2 Dowel Bar Bond Breaker

A bond breaker shall be used over the dowel bar coating. When a shop-applied bond breaker is used, it shall meet the requirements of AASHTO M-254. Field-applied bond breakers shall be lubricating oil, form oil, or similar that will prevent the bonding of the dowel bar to the concrete and shall not be harmful to the concrete.

3.9.3 Grout Retention Rings

Grout retention rings shall be used when dowels are inserted into holes created using percussion drills. The rings shall be made of non-corrosive material.

3.9.4 Expansion Sleeves

The sleeves for dowel bars used in expansion joints shall be made of non-corrosive material and designed to cover 2 to 3 inches of the dowel ends. It shall have a closed end and a suitable stop to hold the end of the dowel bar at least 1 inch from the closed end of the sleeve. Sleeves shall be of such design that they shall not collapse during construction.

3.9.5 Dowel Anchoring Grout Material

Grout for anchoring dowels at construction joints shall be non-sag material and shall conform to the compressive strength, modulus, and linear coefficient of shrinkage requirements for ASTM C 881, Type IV, Grade 3 material. Temperature class shall be appropriate for expected ambient installation temperatures.

3.9.6 Dowel Basket Assemblies

Dowel basket assemblies shall provide rigid support to prevent dowels from becoming misaligned during paving operations.

3.10 Evaporation Retardants

Monomolecular evaporation retardants shall be used in accordance with manufacturers' instructions.

3.11 Curing Materials

Curing materials shall have water-retention properties in accordance with **[ASTM C 309] [the requirements established by [the _____________ Department of Transportation] [ ]]**.

****

ASTM C 309 restricts water loss to a given volume over a fixed period of time. However, several State Department of Transportations restrict the water loss to a quantity less than specified by ASTM. Depending on local experience, the Engineer may specify the local State Department of Transportation or other requirement for curing.

****

4.0 CONCRETE MIXTURE

4.1 Concrete Mixture Requirements

The concrete mixture shall meet the following:

1. Concrete shall be designed to achieve a 28-day flexural strength of **[600] [ ]** psi. The Contractor shall target production concrete quality to achieve PWL of 90 or higher for strength.

****
The 14-day or the 28-day concrete flexural strength specified for construction should be 5 percent less than the design concrete flexural strength used for concrete pavement thickness calculations in accordance with FAA AC 150/5320-6D. Thickness design calculations are typically based on the design concrete flexural strength at the time that the pavement will receive aircraft traffic, typically 60 to 90 days after concrete placement.

FAA AC 150/5320-6D recommends that the thickness design calculations be based upon a concrete flexural strength of 600 to 650 psi. Higher design concrete flexural strengths are not recommended due to over-design impacts that can result in brittleness in the concrete and negatively impact concrete durability. Design concrete flexural strengths higher than 650 psi should be coordinated with FAA before incorporation into a project. The Engineer will refer to AC 150/5320-6D, for recommendations for specifying the 28-day concrete flexural strength.
****

2. The minimum cementitious-material content (hydraulic cement plus supplementary cementitious materials) shall be **[470] [517]** pounds per cubic yard.

****
Use 470 pounds in mild and moderate regions, 517 pounds in severe weathering regions.
****

3. The minimum water-to-cementitious-materials ratio shall be 0.38. The maximum water-to-cementitious-materials ratio shall be **[0.45] [0.50]**.

****
A maximum water-cementitious-materials ratio of 0.45 is adequate for severe weathering regions. In moderate and mild/negligible weathering regions, a maximum ratio of 0.50 is adequate. The weathering regions are defined in ASTM C 33. Local experience shall also be applied to establish the weathering category for a region.
****

4. The supplementary cementing material use shall be as follows:

    a. When used with ASTM C 150 cements:

    i. Fly ash – not to exceed 25% of total cementitious material
    ii. GGBFS – not to exceed 50% of total cementitious material
    iii. If both fly ash and GGBFS are used, the total supplementary cementing material shall not exceed 50% of total cementitious material

b. Total supplementary cementitious content shall not exceed 50% for mixtures using ASTM C 595 or ASTM C 1157 cements.
c. In case of reactive aggregates, the use of the supplementary cementing material shall be governed by the Contractor's reactive aggregate mitigation plan, as per Para. 3.2.3 – Aggregate Reactivity.

5. **[The target percentage of air in the mixture shall be based upon the [severe] [moderate] [mild] exposure condition and maximum aggregate size in accordance with ASTM C 94/C 94M. Air content shall be determined by testing in accordance with ASTM C 231 or ASTM C 173/C 173M, as appropriate.]**

****
The Engineer will determine the exposure condition. The Contractor shall select the air content appropriately based on the maximum aggregate size in accordance with ASTM C 94/C 94M. The specific test method to be used to determine the air content shall be based on aggregate type.
****

4.2 Concrete Mixture Proportions

The Contractor shall submit the concrete mixture proportions and the combined aggregate gradations for each concrete mixture proposed for use in the work. The concrete mixture submittal shall include the maximum aggregate size and the target air content. The concrete mixtures shall be optimized to facilitate concrete placement, consolidation, and finishing.

The water-to-cementitious materials ratio of each approved concrete mixture is designated as the approved maximum water-to-cementitious materials ratio for that mixture.

In accordance with the Contractor's option, the concrete mixture submittal shall include the flexural strength versus the splitting tensile strength correlation data in accordance with the requirements of Para. 9.4.2.2 – Strength Method 2 – Splitting Tensile Strength using Cylinders.

Changes in the source of any of the concrete ingredients, including cement clinker, requires submission of a new concrete mixture proportion that shall meet the specified concrete mixture requirements.

****
The Engineer will review the concrete mixture submittal for conformance with the specification before the concrete is delivered to the project site. The mixture's target air content will be verified for the maximum aggregate size and the exposure condition in accordance with ASTM C 94/C 94M.
****

5.0 EQUIPMENT

The Contractor shall furnish all equipment and tools necessary for handling materials and performing all parts of the concrete pavement construction.

5.1 Concrete Batching Plant

The concrete batching plant shall be designed and operated to produce concrete within the specified tolerances and shall conform to the requirements of the NRMCA QC3 document **[or State of ___________ Department of Transportation]**. In addition, the concrete uniformity requirements given in Para. 5.1.4 - Concrete Uniformity Tests, shall be met.

****
Engineer may allow a State DOT certification for the concrete batching plant.
****

5.1.1 Existing Plant Certification

Batch plants that have current NRMCA QC3 certificates signed by a Professional Engineer **[, or _________________Department of Transportation certification,]** may be used without recertification or inspection for this project, in conformance with the requirements of that certification. The NRMCA QC3 checklist shall be performed for plants that are moved.

****
Engineer may allow a State Department of Transportation certification for an existing operational plant.
****

5.1.2 Plants without Certification

The Contractor shall complete NRMCA QC3 checklist for each concrete plant to be used for the work. Each plant shall pass in all categories. Trucks for truck-mixed concrete, when used, shall also pass the NRMCA QC3 checklist. The NRMCA provided certificates are not required.

The NRMCA QC3 checklist shall be performed not more than 6 months from the start of production paving. In addition, the checklist inspection shall be repeated when the plant is relocated.

Personnel performing the inspection in accordance with the NRMCA QC3 checklist shall provide documentation of knowledge of batch plant operations and concrete production. A Statement of Qualifications shall be maintained for all personnel involved in the inspection process and shall include:

- Name and present company title.
- Date of preparation of the Statement of Qualifications.
- Years of service with the present company.

- Job titles and dates of service of prior positions held within the company.
- Years of service with other companies that produce concrete, concrete contractors, testing laboratories, or other companies that provide experience with concrete technology and concrete construction.
- Training related to concrete production.

The Engineer will review and approve qualifications of the plant inspector.

Documentation to validate that the plant has been inspected shall be submitted to the Engineer and maintained at the batch plant.

5.1.3 Mixers

Mixers shall be capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. The mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixer drums shall be kept free of hardened concrete. Mixer blades or paddles shall be replaced when worn more than 10 percent of their depth, when compared with the manufacturer's dimension for new blades or paddles and included with the mixer submittal.

5.1.4 Concrete Uniformity Tests

Concrete mixer uniformity tests shall be conducted on central mix plants and truck mixers before production of the project concrete. Uniformity tests shall also be conducted for all batch plants that are moved.

Criteria for mixer uniformity in accordance with ASTM C 94/C 94M shall be met.

The number of revolutions for truck-mixed and shrink-mixed concrete shall be determined by uniformity tests in accordance with ASTM C 94/C 94M.

5.2 Concrete Hauling Equipment

All concrete hauling equipment shall be operated to deliver and discharge the required concrete mixture completely without segregation.

5.3 Transfer and Spreading Equipment

Use of transfer and spreading equipment shall be at the Contractor’s option. Such equipment, when used, shall not segregate or contaminate the concrete.

5.4 Paving Equipment

The paving equipment shall be capable of placing and consolidating the concrete uniformly across the width of placement. The equipment shall shape the concrete to the specified cross section. Rotary trowels or other equipment that can burn or polish the concrete surface shall not be used to finish the concrete surface.

Paving equipment shall be fitted with internal vibrators and be equipped with a vibrator monitoring device that indicates the frequency of each installed vibrator. The vibrator mounting shall allow adjustments to the vibrator depth and attitude. Hand held vibrators are not considered internal vibrators and shall be used only for hand placement areas.

5.5 Texturing Equipment

The texturing equipment shall provide uniform surface texture in plastic concrete across the full width of the paving lane. The texture shall be applied with a **[brush] [or] [broom], [burlap drag] [,] or] [artificial turf finish]**. The texturing equipment shall be capable of providing an average macrotexture depth of 0.04 inch, plus or minus 0.008 inch, when tested in accordance with ASTM E 965.

****
Engineer may select one or more alternate texture types based on local practice and owner preference.
****

5.6 Curing Machines

The machine for applying membrane-forming curing compound shall be a self-propelled frame that spans the paving lane and provides uniform curing material coverage at the specified rate on the concrete surface and any exposed edges. Self-propelled curing machines are required when the paving lane for any day is larger than **[250] [ ]** square yards.

****
Minimum size of paving lane to require self-propelled curing machine may be determined by the Engineer. Generally, when the area is large enough to accommodate a slipform or a side-form paver, then a self-propelled curing machine shall be used.
****

Hand-operated sprayers shall only be used where forms have been removed, when the paving lane for any day is equal to or less than **[250] [ ]** square yards or on odd-shaped slabs where there is insufficient clearance for self-propelled curing machine to operate.

5.7 Concrete Saws

Equipment for sawing joints and for other similar sawing of concrete shall be mounted on a wheeled-chassis, which can be easily guided to follow the required alignment. All saws shall be capable of sawing to the depth specified in a single pass.

The Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions in a timely manner. The Contractor shall provide standby saws in good working order and a supply of saw blades at the site at all times during sawing operations.

5.8 Drills

Rigs for drilling holes for dowels in construction joints shall be capable of drilling holes at proper alignment without chipping and spalling beyond the area covered by the grout-retention ring. Hand-held drills shall only be used in isolated areas where there is insufficient clearance for gang-mounted drill rig.

6.0 WEATHER MANAGEMENT

[The Contractor shall submit, for the Engineer's review, a Weather Management Plan for paving in hot weather and/or cold weather, as applicable, and for protective measures in case of imminent rainstorm. The plan shall be submitted before start of concrete paving. The Contractor shall indicate the weather station to be used for monitoring the weather. The Plan shall include the following, as a minimum.]

[The Contractor shall meet the following requirements for paving in hot weather and/or cold weather, as applicable, and for protective measures in case of imminent rainstorm. The Contractor shall indicate the weather station to be used for monitoring the weather.]

****
A Weather Management Plan is not required for small projects. The Engineer should select the second paragraph for small projects.
****

6.1 Hot Weather Paving

Hot weather paving is defined as paving when the concrete temperature at the paver is greater than 85 degrees F or the moisture evaporation rate at the concrete surface is greater than 0.20 lb/square foot/hour or greater than 0.10 lb/square foot/hour for concrete mixtures containing SCMs, as determined using the American Concrete Institute (ACI) moisture evaporation rate chart.

[The Weather Management Plan for hot weather paving shall incorporate the applicable recommendations of ACI 305 – Hot Weather Concreting and other industry-accepted

procedures to mitigate any problems resulting from hot weather concrete placement, especially, plastic shrinkage cracking due to late curing and full-depth cracking due to late sawing. The use of evaporation retarders, to minimize surface moisture loss and occurrence of plastic shrinkage cracking, shall be addressed in the Weather Management Plan.]

[The Contractor shall take necessary precautions, including use of evaporation retarders, to minimize surface moisture loss and occurrence of plastic shrinkage cracking, and correct timing of sawcutting to avoid random cracking.]

****
A Weather Management Plan is not required for small projects. The Engineer should select the second paragraph for small projects.
****

Maximum allowable concrete temperature after depositing in front of the paving equipment is 95 degrees F. The Contractor shall be aware that concrete placement difficulties may be encountered when the temperature of the delivered concrete exceeds 85 degrees F.

For side-form paving, the steel forms shall be cooled or protected as necessary to keep the steel form temperature below 120 degrees F.

[Contractor's Weather Management Plan shall include provisions for placement of concrete with temperature greater than 95 degrees F for short lengths, not exceeding 200 ft per day to expedite concrete placement activities. These provisions shall include use of mitigation methods, such as curing blankets and fog spraying for a period of 72 hours after concrete placement. Fog spraying shall not result in ponding on the concrete surface.]

****
The Engineer should select above paragraph for large projects.
****

6.2 Cold Weather Paving

[The Weather Management Plan for cold weather paving shall incorporate the applicable recommendations of ACI 306 – Cold Weather Concreting. The Plan shall include provisions to ensure that concrete production is consistent during cold weather, that concrete with adequate workability and early-age strength is delivered to the project site, and the temperature of fresh concrete is 50 degrees F or higher at the location of placement. The Plan shall also include provisions for adequate protection of concrete to retain the heat of hydration during cold weather.]

[The Contractor shall take necessary precautions to ensure that concrete production is consistent during cold weather, that concrete with adequate workability and early-age strength is delivered to the project site, and the temperature of fresh concrete is 50 degrees F or higher at the location of placement. The Contractor shall provide for adequate protection of concrete to retain the heat of hydration during cold weather.]

****
A Weather Management Plan is not required for small projects. The Engineer should select the second paragraph for small projects.
****

Concrete shall not be placed when the temperature of the air at the site is 40 degrees F and dropping or the surfaces on which the concrete is to be placed is less than 32 degrees F.

Concrete pavement surface temperature shall be maintained at or above 32 degrees F for a period of at least 72 hours or until in-place concrete compressive strength of 500 psi is attained. Corners and edges are the most vulnerable to freezing and shall be adequately protected. Coverings and other means of protecting the concrete from freezing shall be available before starting placement in cold weather and used as necessary.

Concrete strength shall be monitored using maturity sensors that record the temperature of the pavement at 15 minute or shorter intervals. The sensors shall be placed within 6 inches from the pavement edge and approximately 2 inches below the surface. The sensors shall be placed within the last 50 feet placement of the day. These sensors shall be monitored to determine when the maturity equivalent of 500 psi is achieved. Protective insulation may be removed after the pavement reaches the maturity equivalent of 500 psi.

Concrete is considered damaged by freezing if any of the following conditions are allowed to occur:

1. Concrete placement when the temperature of the air at the site is 40 degrees F and dropping or the surface on which the concrete is to be placed is less than 32 degrees F
2. Concrete pavement surface temperature is not maintained at or above 32 degrees F for a period of at least 72 hours or until in-place concrete compressive strength of 500 psi is attained

Slabs with damaged concrete are considered defective and shall be mitigated as per Para. 10.2 – Defective Pavement.

6.3 Protecting Concrete from Rain Damage

[Contractor's Weather Management Plan shall include provisions to protect the freshly placed concrete from rain damage.]

The Contractor shall not place concrete when rain conditions appear imminent. The Contractor shall maintain on-site sufficient waterproof material and means to rapidly place it over all unhardened concrete surface or concrete surface that may be damaged by rain. Concrete shall not be placed during rain that results in any standing water on the surface of the fresh concrete surface.

Rain-damaged concrete shall be cored as directed by the Engineer and depth of damage determined by petrographic examination. When the depth of damage is 1/4 inch or less of the pavement thickness, the damaged areas shall be corrected by diamond grinding. Diamond grinding requirements are detailed in Para. 10.1.2.1 - Surface Grinding. Coring and grinding shall be at the Contractor's expense. Diamond grinding and related activities shall be at the Contractor's expense.

If depth of damage is greater than 1/4 inch, the slab shall be considered defective and mitigated as per Para. 10.2 – Defective Pavement.

7.0 EXECUTION

7.1 Underlying Material Preparation

Before setting forms or placing concrete, the underlying material shall be accepted by the Engineer for concrete placement. The underlying material shall have been satisfactorily graded, including at the thickened edge locations. The underlying material shall be clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water.

Underlying material disturbed by construction operations shall be reworked in accordance with the appropriate specification.

****
For slipform paving, typical sections shall include at least 3 feet additional width for all layers beneath the concrete at the outer paving lanes to support the tracks. These quantities shall be included in the plan quantities.
****

7.2 [Not Used] [Paving on Stabilized Bases

Paving on stabilized bases shall require treatment [as shown on plans] [contained in Item P-______] [as follows:]]

****
Paving on stabilized bases requires specific design considerations to prevent early age cracking. These considerations include use of a geo-fabric, a choke stone layer, or another treatment. The Engineer will show requirements on plans and in appropriate stabilized base item or insert language into this specification.
****

7.3 Test Section

[A test section shall be constructed. The test section shall be the first day of paving with a minimum length of 400 ft and a maximum of one lot, as designated in Para. 9.2 – Lot Size. The test section area shall be considered as single lot. The test section width shall be [the

predominant] [the widest] [width of the production paving area] [feet], and the thickness shall be [inches] [the predominant section thickness] [the thickest section].]

[A test section shall be constructed. The test section shall be the first day of paving with a minimum length representative of production paving of 100 feet and a maximum length equivalent to 10 percent of the total concrete production for the selected paving method. The test section area shall be considered as single lot, irrespective of the length of the test section. The test section width shall be [the predominant] [the widest] [width of the production paving area] [feet], and the thickness shall be [inches] [the predominant section thickness] [the thickest section].]

****

The width and thickness will be selected by the Engineer to represent the predominant paving lane condition.

For small projects, with concrete production less than about 10,000 cubic yards, the second paragraph requirements shall be specified.

****

Whenever possible, the test section shall be part of the production paving outside of the main gear traffic areas in a location agreed upon with Engineer and where the underlying layer has been accepted.

7.3.1 Test Section Requirements

The Contractor shall demonstrate that the concrete can be placed to the specified requirements at the test section. The Contractor shall place concrete and adjust the concrete mixture, as necessary, within the limits specified in Para. 7.4 – Production Paving Adjustments to the Concrete Mixture Proportions. The Contractor shall adjust equipment and modify procedures, as necessary, such that when the start of the test section is designated, the specified end product is attained.

During the test section placement, the Contractor shall demonstrate control of the construction process, including concrete mixing, transporting, placing, consolidation, finishing, application of curing, construction of contraction joints and headers, and the performance of the Contractor's process control and acceptance testing.

The Contractor shall designate the start of the test section after he has determined that his concrete mixture and his construction process can produce a concrete pavement that is in conformance with the plans and specifications. Concrete placed prior to the start of the test section shall be removed and replaced.

The test section shall be deemed acceptable when it meets the process control and acceptance testing criteria with no deficient or defective pavement and when the test section achieves a percent within limits (PWL) of 90 or higher for thickness. Strength testing for the test section shall be performed at a later date in accordance with Para. 9.4.2 - Strength. Strength acceptance for the test section shall be in accordance with Para. 9.4.2.3 – Strength Acceptance. The process control and acceptance test results shall be provided to the Engineer in writing.

Test section determined to be not-acceptable shall be mitigated in accordance with Para. 10.0 – Deficient and Defective Pavement and a new test section shall be constructed.

The concrete mixture proportions used in the accepted test section shall be designated as the approved concrete mixture for production paving.

Production paving shall not be started until the test section has been accepted by the engineer. The materials, process and level and skill of the workforce used for the conforming test section shall be maintained throughout production paving.

When the concrete plant or plant type changes, the Contractor shall validate the new process by constructing another test section.

7.4 Production Paving Adjustments to the Concrete Mixture Proportions

Production paving concrete mixture proportions shall be adjusted to achieve uniformity in the properties of fresh concrete, to maintain concrete workability, and to provide the specified properties for the fresh and the in-place concrete. The following field adjustments to the approved concrete mixture, as established by the laboratory testing are permitted, without requiring a new submittal for the concrete mixture proportions:

1. Individual aggregate proportions may be adjusted as necessary within the limits of Para. 8.3.4 – Combined Aggregate Gradation.

2. As necessary, cementitious materials may be increased by up to 10 percent by mass of the approved mixture proportions. Cementitious material content shall not be reduced from the approved mixture proportions.

3. As necessary, cement may be replaced with the approved SCM in an amount not to exceed 10 percent of the original SCM mass. When applicable, the Contractor's mitigation plan for reactive aggregates shall be re-evaluated.

4. As necessary, any SCM may be replaced with the approved cement. When applicable, the Contractor's mitigation plan for reactive aggregates shall be re-evaluated.

5. Quantities of admixtures may be adjusted in accordance with the manufacturer's recommendations.

6. Field adjustment for water is permitted provided that the water-cementitious materials ratio does not exceed the ratio for the approved concrete mixture and is not less than that listed in Para. 4.1 – Concrete Mixture Requirements.

7. For truck mixed concrete, additional water may be added only once to adjust the workability of concrete, provided the approved water-to-cementitious-materials ratio is not exceeded. The maximum amount to be added shall be adjusted based upon the volume of concrete already discharged. The drum or blades shall be turned a minimum of 30 additional revolutions at mixing speed after water addition.

8. Water addition to the concrete by spraying in front of and behind the paving equipment is not allowed.

7.5 Tie Bar Placement

Deformed tie bars shall be installed as shown on the plans. Tie bars shall be placed parallel to the pavement surface and in the middle of the slab depth. Tie bars shall not be greased or enclosed in sleeves.

Tie bars shall not be placed within 15 inches of intersecting doweled joints.

7.6 Doweled Contraction Joints

The dowel bars shall be of the dimensions and spacing as shown on the plans. The bars shall be installed as shown on the plans. The portion of each dowel shown on the plans to receive a bond-breaker lubricant shall be thoroughly coated to prevent the concrete from bonding to that portion of the dowel.

The maximum permissible tolerances on dowel bar alignment shall be in accordance with Para. 9.3.4 – Dowel Bar Alignment.

7.7 Doweled Construction Joints

Dowel bars, as shown on the plans, shall be placed along construction joints by grouting the dowels into holes in the hardened concrete. Insertion of dowel bars using automated devices into plastic concrete along construction joints is not allowed.

Holes for dowels shall be approximately 1/8 inch to 1/4 inch greater in diameter than the dowel diameter and shall not exhibit excessive chipping and spalling or dislodging of aggregate particles around the holes.

Dowels shall be anchored in the holes using approved grout material. Installation procedures shall be adequate to ensure that the space around dowels is completely filled with the grout. Bars shall not be withdrawn and reinserted after being in contact with the grout.

Dowel bars shall not be placed within 15 inches of intersecting doweled joints.

The Contractor shall check the position and alignment of the grouted dowel bars. The maximum permissible tolerances on dowel bar alignment shall be in accordance with Para. 9.3.4 – Dowel Bar Alignment.

7.8 Doweled Expansion Joints

A dowel expansion cap or sleeve shall be furnished for each dowel bar used with expansion joints. These caps shall be rigid 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 expansion gap allowable shall be as shown on the plans.

The maximum permissible tolerances on dowel bar alignment shall be in accordance with Para. 9.3.4 – Dowel Bar Alignment.

7.9 Concrete Production

Concrete shall be mixed and produced according to the procedures demonstrated at the test section.

7.9.1 Batch Tickets

Every load of concrete delivered to the paving site shall have a batch ticket indicating all of the information identified in the NRMCA QC3 document for batch tickets. For truck-mixed concrete, the batch tickets shall also show the amount of water that can be added without exceeding the approved water-to-cementitious-materials ratio. Batch tickets for central-mixed concrete delivered in trucks that do not have the capability of adding water may be retained at the plant and delivered to the Engineer daily.

7.10 Hauling

Haul time is defined as the elapsed time from the addition of cementitious material into the mixture until the paving equipment has passed over the concrete. Haul time shall not exceed 45 minutes when the concrete is hauled in non-agitating trucks, or 105 minutes when the concrete is hauled in truck mixers or truck agitors. Concrete shall be transported to the point of discharge without segregation. Concrete that has been deposited, but whose haul time exceeded the specified limits before the paving equipment passes over the concrete, shall be removed.

During hot weather, as defined in Para. 6.1 – Hot Weather Paving, the haul time shall not exceed 30 minutes when the concrete is hauled in non-agitating trucks, or 90 minutes when the concrete is hauled in truck mixers or truck agitors.

7.11 Paving

The Contractor shall place, spread, consolidate, and finish the concrete to meet the requirements of Para. 9.0 – Acceptance Testing. The paving operation shall result in a dense concrete matrix that does not exhibit segregation. Hand-finishing operations behind the paver shall be kept to a minimum to correct minor surface defects.

Hand placement of concrete shall not be permitted, except under the following conditions:

1. In the event of breakdown of the paving equipment, hand placement methods may be used to consolidate and finish the concrete already deposited on the grade
2. In areas of narrow widths or of irregular dimensions where operation of the paving equipment is not practical.

The hand placed concrete, as soon as placed, shall be consolidated, struck off and screeded. Concrete consolidation shall be achieved using hand held or other vibrators. The screed shall be at least 2 feet longer than the maximum width of the slab to be struck off. Hand placed concrete shall result in a dense concrete matrix that does not exhibit segregation.

Surface texture shall be applied after the finishing activities and after the bleed water disappears. The texturing equipment shall not tear or dislodge aggregates from the pavement surface during the operation. Any imperfections resulting from the texturing operation shall be corrected.

7.12 Curing

Concrete shall be continuously protected against loss of moisture for at least 72 hours after the completion of finishing operations. Curing shall be accomplished by use of curing compounds or by moist curing.

When a curing compound is used, it shall be applied using a curing machine immediately after the surface texture has been applied. Curing shall be applied at a coverage rate that is the smaller of 150 square feet per gallon or that recommended for paving applications by the manufacturer. When discontinuities exist in the applied curing material, an additional coat shall be applied to the affected areas within 30 minutes of the initial curing application. Areas where the curing compound application is allowed by hand-operated sprayers, a second coat shall be applied in a direction approximately at right angles to the direction of the first coat. If any curing machine or hand-operated sprayer fails to apply an even coating of the compound at the specified rate, it shall be replaced and the pavement area in question re-sprayed.

If any drying of the concrete surface has occurred before application of curing compound, the surface of the concrete shall be immediately fog sprayed, and the curing compound applied as soon as the free water disappears.

Curing shall not be applied to pavement surface that has standing water as a result of a rainfall. Curing shall be applied as soon as the standing water has evaporated and the surface is still damp.

7.12.1 Curing Protection

Areas where the curing compound is damaged by subsequent construction operations within the first 72-hour curing period shall be immediately re-sprayed. Concrete surfaces to which curing compounds have been applied shall be adequately protected to prevent damage from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane. Curing compound that has been damaged by rainfall shall be re-sprayed as soon as practical at the specified coverage rate.

7.13 Form Removal

Forms shall remain in place at least for 12 hours or until the in-place concrete has attained a compressive strength of 500 psi. Concrete strength shall be monitored using maturity sensors that record the temperature of the pavement at 15 minute or shorter intervals. A sensor shall be placed within 6 inches from the pavement edge and approximately 2 inches below the surface in the last 50 feet of placement. These sensors will be monitored to determine when the maturity equivalent of 500 psi is achieved. Forms may be removed after the pavement reaches the maturity equivalent of 500 psi.

Forms shall be removed by procedures that do not damage the concrete. Curing compound shall be applied at the specified rate immediately to the faces exposed after form removal.

7.14 Sawcutting

Joints shall be cut as shown on the plans using equipment described in Para. 5.8 – Concrete Saws. The initial sawcut shall produce a slot at least 1/8 inch wide and to the depth shown on the plans.

Sawing shall start as soon as the concrete has hardened sufficiently and before cracking of the pavement occurs. Chipping, raveling, or tearing of the concrete due to cutting, which exceeds the dimension of the sealant reservoir width, is not allowed. Sawing shall be carried on both during the day and night as required.

After sawing, the slurry and laitance shall be immediately washed from the pavement before it dries. Curing treatment shall be reapplied to the cleaned sawed surfaces within 60 minutes of sawing. Temporary backer rod shall be inserted into the joint. The backer rod shall be one size larger than the initial sawcut and no more than 1/4 inch below the top surface of the slab. Temporary backer rod shall be maintained and remain in place until the second sawcut in preparation for joint sealing. Temporary backer rod shall not be reused as part of the joint sealing operation.

The second sawcut at the joints, when specified in the plans, shall produce a sealant reservoir with the dimensions as shown on the plans.

7.15 Opening to Construction Traffic

The newly constructed concrete pavement shall not be open to construction traffic, except for saw-cutting equipment, until all of the following requirements are met:

1. The curing compound is sufficiently hardened to prevent damage from vehicle traffic.
2. The joints are sealed or protected from damage to the joint edge and from intrusion of foreign materials into the joint. As a minimum, backer rod or tape shall be used to protect the joints from foreign matter intrusion.
3. The minimum in-place concrete flexural strength is:

a. Default flexural strength of 450 psi, or
b. Equal to or more than the Zero Fatigue Stress. The Zero Fatigue Stress is the larger value of:
    i. 300 psi, and
    ii. The calculated maximum concrete pavement edge bending stress due to the critical construction equipment multiplied by 2.5. The edge bending stress shall be computed using a procedure approved by the Engineer, and shall be based on the estimated in-place concrete properties at the time of construction traffic use. The estimated in-place concrete properties shall be verified using a procedure approved by the Engineer.

The flexural strength of the concrete shall be determined using one of the following methods:

1. Beam testing - A total of three beams shall be prepared using concrete from the most recently placed sublot that will be subjected to construction traffic. The beams shall be prepared and cured at the site in accordance with ASTM C 31. The beams shall be tested in accordance with ASTM C 78. The average flexural strength shall be designated as the in-place concrete strength.
2. Cylinder testing - A total of three cylinders shall be prepared using concrete from the most recently placed sublot that will be subjected to construction traffic. The cylinders shall be prepared and cured at the site in accordance with ASTM C 31. The cylinders shall be tested for splitting tensile strength in accordance with ASTM C 496/C 496M. The flexural strength shall be determined by dividing the splitting tensile strength by the correlation ratio, COR, developed as per Para. 9.4.2.2 - Strength Method 2 – Splitting Tensile Strength using Cylinders. The average flexural strength shall be designated as the in-place concrete strength
3. Other method approved by the Engineer, including maturity testing. If maturity testing is used, in-situ concrete strength shall be monitored using maturity sensors that record the temperature of the pavement at 15 minute or shorter intervals. The sensors shall be placed within 6 inches from the pavement edge and approximately 2 inches below the surface in the most recently placed sublot that will be subjected to construction traffic.

8.0 PROCESS CONTROL

The Contractor shall perform all tests as necessary to monitor the concrete production and concrete pavement construction processes to produce a pavement that meets the specifications. The Contractor shall submit a Quality Control Plan in accordance with Section 100 of the General Provisions that addresses the Contractor's overall quality processes and testing requirements for process control. The Contractor shall maintain copies of the specified test and material standards at the project site.

The Contractor's Quality Control Plan shall indicate the appropriate actions that shall be taken when the concrete production and the concrete pavement construction processes are determined to be out of control.

The Contractor's Quality Control Plan shall also address the acceptance testing to be performed by the Contractor as per Para. 9.4 – Contractor Performed Acceptance Testing.

The Contractor shall allow the Engineer to observe the process control testing. The Engineer shall be provided a written copy of the results within 72 hours of completion of a day's paving.

8.1 Testing Personnel

Contractor testing personnel shall be certified as follows:

1. Field testing technicians: American Concrete Institute (ACI) Concrete Field Testing Technician.
2. Laboratory testing technicians (non-strength testing): ACI Concrete Laboratory Testing Technician, Grade I or II.
3. Laboratory strength testing technicians: ACI Concrete Strength Testing Technician.

Certification at an equivalent level by NICET, a state, or a nationally recognized organization is also acceptable.

8.2 Testing Laboratory Requirements

The Contractor's testing laboratories shall meet the requirements of ASTM C 1077 that relate to the minimum technical requirements for laboratory equipment utilized in testing concrete and concrete aggregates for use in construction or be accredited by **[ ] [Department of Transportation]** or AASHTO for concrete testing. The Contractor's curing process for strength specimens shall meet the requirements of ASTM C 31.

****
Add appropriate State name or highway, aviation or transportation agency designation
****

8.3 Process Control Testing

During construction, the Contractor shall be responsible for sampling and testing aggregates, cementitious materials, and concrete to determine compliance with the specifications. The Contractor shall perform, as a minimum, the inspection and tests described below. Based upon the results of these inspections and tests, the Contractor shall take the action required to maintain processes under control and submit reports as required. The Contractor, regardless of any other testing performed by the Engineer, shall perform the specified process control inspection and testing.

Lot size and sublot requirements are defined in Para. 9.2 – Lot Size.

8.3.1 Accuracy of Plant Batching

During production paving, the accuracy of plant batching shall be rechecked in accordance with the provisions of NRMCA QC 3 document at the frequency stated in the NRMCA QC 3 document. When any requirements relating to the accuracy of batching of NRMCA QC 3 document are not met, the plant operation shall be stopped and concrete production shall not be restarted until corrective measures have been implemented to bring the plant into compliance.

8.3.2 Aggregate Quality

Testing, as per Para. 3.2.2 - Aggregate Quality**,** to determine deleterious substances and flat and elongated pieces for aggregate retained on the No. 4 sieve shall be conducted on the day of test section construction and on every seventh day of paving thereafter.

The aggregate quality tests shall be performed a representative sample obtained from each aggregate stockpile at the plant site. When the specified quality requirements not met, the test(s) shall be repeated on another sample. When the specified requirements of the tests are not met for the second test(s), the affected aggregate stockpile shall be rejected and replaced with conforming aggregates.

8.3.3 Combined Aggregate Gradation

Grading for each aggregate type shall be determined at least once per day for each day of paving, in accordance with ASTM C 136 on samples representative of that day's paving. The mathematical combined aggregate gradation shall be determined using the aggregate proportions of the approved concrete mixture.

8.3.3.1 WF and CF

The Workability Factor (WF) and the Coarseness Factor (CF), as defined in Para. 3.2.1.1 - Standard Method of Evaluation, of the mathematical combined aggregate gradation shall be determined. The combined aggregate gradation tolerance is plus or minus 3 points for the WF and plus or minus 5 points for the CF from the WF and CF values established for the approved concrete mixture.

8.3.3.2 Combined-Aggregate Gradation Controls

If the combined aggregate gradation is not within tolerance, the Contractor shall make adjustments in the aggregate proportions. If the adjustments can not be adjusted to within the specified tolerance, the affected aggregate stockpile shall be rejected.

8.3.4 [Not Used] [Air Content

One air content test shall be performed for each sublot of concrete material produced. Air content tests shall be performed in accordance with ASTM C 231 or ASTM C 173/C 173M,

as appropriate, from material randomly sampled from trucks at the paving site. Material samples shall be obtained in accordance with ASTM C 172.

The specified acceptance criteria for air content in Para. 4.1 – Concrete Mixture Requirements shall be achieved with a tolerance of plus or minus 1.5 percent for any individual test. When the criteria are not met for the first test, the test shall be repeated on another sample from that load. If the second test fails, conduct testing on the next available truck. Unloading of the concrete at the paver shall be stopped unless the truckload passes the air content requirement. Test each truck until three consecutive truckloads pass the air content test. Then, the testing for air content shall be continued on the basis of one test per sublot.]

****
Air content testing is required only when there is a requirement for target percent of air in the concrete mixture in Para. 4.1 – Concrete Mixture Requirements.
****

8.3.5 Concrete Temperature

One concrete temperature test shall be performed for each sublot of material. Concrete temperature tests shall be performed in accordance with ASTM C 1064 from material randomly sampled from trucks at the paving site. The acceptance criteria for concrete temperature specified in Para. 6.0 - Weather Management Plan, shall be met. When the criterion is not met for the first test, the test shall be repeated on another sample from that load. If the second test fails, conduct testing on the next available truck. Unloading of the concrete at the paver shall be stopped unless the truckload passes the temperature requirement. Test each truck until three consecutive truckloads pass the temperature requirement. Then, the testing for temperature shall be continued on the basis of one test per sublot.

8.3.6 Hand Finishing at Edges

Hand finishing of the edges and corners of the concrete surface behind the paving equipment shall be limited to 25 percent of the edge per slab. Hand finishing of the edges and corners in excess of 25 percent of the edge per slab indicates that the process is not in conformance and the Contractor shall make the necessary adjustments in the concrete proportions and construction process.

Use of cutting straightedges on the slab surface is not considered hand finishing.

Addition of water to the surface of the concrete pavement behind the paving equipment is not allowed.

8.4 Control Charts

The Contractor shall maintain linear control charts for combined aggregate WF and CF values; air content, when applicable; and concrete temperature.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept up to date at all times. The Contractor shall use the control charts as part of a process control system for identifying potential problems before they occur.

9.0 ACCEPTANCE TESTING

Testing shall be performed to determine compliance with the specifications. Testing shall be performed by the Engineer and the Contractor, as designated in this section.

The Contractor shall make provisions to allow the Engineer to observe acceptance testing by the Contractor to verify the Contractor's procedures. The Engineer shall be notified of the results of the Contractor acceptance testing in writing within 72 hours of completion of testing.

9.1 Control Charts

The Contractor shall maintain linear control charts for the acceptance tests. Control charts shall be posted in a location satisfactory to the Engineer and shall be kept up to date at all times. The Contractor shall use the acceptance control charts as additional input for his process control and for identifying potential construction problems before they occur.

9.2 Lot Size

A lot shall consist of:

[ ] cubic yards]
[ ] square yards]
[the smaller of a day's production or 2,000 cubic yards]
[the smaller of a day's production or [ ] square yards]

Each lot shall be divided into 5 equal sublots. Sampling locations shall be determined in accordance with random sampling procedures contained in ASTM D 3665.

****
The Engineer shall specify the lot size for a project based on the total quantity and the expected production rate.

For production paving, use of a lot size of 2,000 cubic yards is recommended and a sublot should be 400 cubic yards. The end of the day sublot should not be less than 300 cubic yards. When it is less than 300 cubic yards, that portion of the pavement shall be considered as part of the next day's placement. The partial sublot at the end of the project should be added to the previous sublot in a sequential order.
****

9.2.1 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 the 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.

1. Where three or four sublots have been produced, they shall constitute a lot.
2. Where one or two sublots have been produced, they shall be incorporated into the next or the previous lot, as determined by the Engineer. The actual total number of sublots per lot shall be used in the acceptance criteria calculation.
3. Where only a partial sublot has been produced during any day, it shall be considered as a sublot or it shall be incorporated into the next or the previous sublot, as determined by the Engineer.

9.3 Engineer Performed Acceptance Tests

The following tests shall be conducted on a sublot basis, unless otherwise noted.

9.3.1 Straightedge

As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a 16-foot straightedge **[and device]**. Surface smoothness deviations shall not exceed 1/4 inch based on a 16-foot straightedge placed in any direction on the concrete surface to identify localized irregularities, including placement along and spanning any pavement joint edge.

A slab exhibiting high spots anywhere along the straightedge, not just the maximum deviation between two contact points, of more than 1/4 inch but less than ½ inch in 16 feet shall be considered deficient and mitigated as per Para. 10.1.2 – High Spots.

A slab exhibiting high spots in excess of ½ inch shall be deemed defective and shall be mitigated in accordance with Para. 10.2 – Defective Pavement.

A slab exhibiting low spots that impair surface drainage shall be mitigated in accordance with Para. 10.2 – Defective Pavement.

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Research is on going regarding the application of automated devices that can electronically simulate a straightedge. When such methods are approved by the FAA, the Engineer may elect to include these devices. However, use of a manual 16-foot straightedge is still recommended to identify any localized issues, especially associated with vertical deviations at joints. The Engineer is cautioned that most grading plans to accommodate drainage at intersections and other areas of warping will not meet straightedge requirements. In these areas, the straightedge should be applied to identify trapped water and any joint deviations.

****

9.3.2 Vertical Grade

Vertical deviation from design grade shall not exceed plus or minus 0.04 foot. Areas out of grade tolerance shall be mitigated in accordance with Para. 10.2 – Defective Pavement.

9.3.3 Edge Slump

Edge slump for acceptance shall be measured on hardened concrete using a 10-foot or longer straightedge, placed perpendicular to the edge of the slab.

Slabs with more than 15 percent of the total free edge along the slab edge in excess of 1/4 inch or any edge with a slump exceeding 3/8 inch shall be deemed defective and shall be mitigated in accordance with Para. 10.2 – Defective Pavement.

9.3.4 Dowel Bar Alignment

Dowel bars shall be checked for position and alignment in hardened concrete. The maximum permissible tolerance on dowel bar skew (tilt) in each plane, horizontal and vertical, shall not exceed 1/4 inch per foot of dowel bar. Dowels shall be placed vertically within 1 inch of slab mid-depth, placed longitudinally within 1 inch of planned location across the joint, and spaced horizontally within 1 inch of planned location along the joint.

For construction joints, the dowel bars shall be embedded one-half the dowel length plus or minus 1 inch. For contraction joints, the dowel mid-point shall be located within 2 inches of the joint sawcut.

If the dowel alignment cannot be maintained as specified, concrete placement shall be stopped and not be restarted until corrective measures are implemented to ensure that the dowel placement conforms to the specification requirements.

Slabs with joints exhibiting misaligned dowel bars shall be considered defective and shall be mitigated in accordance with Para. 10.2. – Defective Pavement.

9.3.5 Cracking

A slab panel exhibiting cracking that is 2 inches or less in depth shall be deemed deficient and mitigated as per Para. 10.1 – Shallow Cracking.

A slab panel exhibiting cracking greater than 2 inches in depth shall be considered defective and shall be mitigated in accordance with Para. 10.2 – Defective Pavement.

9.3.6 Sliver Spalls

Sliver spalls are spalls or flakes within 1 inch of the joint face and not extending beyond the depth of the joint seal reservoir. Slabs with sliver spalls over a length less than 15% of any one slab edge shall be deemed deficient and shall be mitigated in accordance with Para. 10.1.3 –

Sliver Spalls. Slabs exceeding this quantity shall be deemed defective and shall be mitigated in accordance with Para. 10.2 – Defective Pavement.

9.3.7 Joint Spalls

Joint spalls are larger and or deeper than sliver spalls. Slabs with spalls over a length less than 15% of any one slab edge shall be deemed deficient and shall be mitigated in accordance with Para. 10.1.4 – Joint Spalls. Slabs with combined sliver and joint spalling exceeding this quantity shall be deemed defective and shall be mitigated in accordance with Para. 10.2 – Defective Pavement.

9.4 Contractor Performed Acceptance Tests

The acceptance test for slab thickness and concrete strength shall be performed by the Contractor and the results shall be used to adjust the pay for the concrete pavement on a lot-by-lot basis.

The Contractor shall allow the Engineer to observe the process control testing. The Engineer shall be provided a written copy of the results within 72 hours of completion of a day's paving.

Concrete 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 determined to be above the lower specification tolerance limit (L).

The PWL shall be determined in accordance with procedures specified in Item 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 Para. 4.2 – Concrete Mixture Requirements
Thickness	Lot Plan Thickness in inches – 0.50 inches

9.4.1 Thickness

Acceptance of each lot of in-place pavement shall be based on PWL. The Contractor shall target production quality to achieve PWL of 90 or higher.

9.4.1.1 Sampling

Slab thickness shall be determined for each sublot at randomly selected locations agreed upon with Engineer. Thickness shall be determined using cores or other methods approved by the Engineer. Areas with planned variable thickness, such as thickened edges, shall be excluded from sample locations.

If cores are used, the cores shall be obtained with a core drill at the rate of one thickness core per sublot. Core holes shall be filled with **[a non-shrink grout] [ ]** approved by the Engineer within one day after sampling. The thickness of the cores shall be determined by the average caliper measurement in accordance with ASTM C 174.

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The engineer may specify a core hole patching material that has performed successfully at the airport.

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9.4.1.2 Thickness Acceptance

The lot shall be accepted or rejected on the basis of Para. 12.1 – Basis for Pay Adjustment.

9.4.2 Strength

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

Concrete strength shall be determined using beams or cylinders as described below. The Contractor shall elect one method for strength testing and this method shall be used to determine strength, once production paving has started.

One sample shall be taken for each sublot from the fresh concrete delivered to the job site. Samples of concrete for strength testing shall be obtained at the point of delivery to the paver, but may be transported to an on-site laboratory for specimen fabrication, curing, and storage. The concrete shall be sampled in accordance with ASTM C 172.

9.4.2.1 Strength Method 1 - Flexural Strength using Beams

Two specimens shall be made from each sample for a sublot. Specimens shall be made and cured in accordance with ASTM C 31 and the flexural strength of each specimen shall be determined at the specified age 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.

9.4.2.2 Strength Method 2 – Splitting Tensile Strength using Cylinders

During the laboratory phase, the Contractor shall determine a correlation between beam flexural strength and cylinder splitting tensile strength at the specified testing age for each concrete mixture to be used for the work. The correlation shall be used to establish the flexural strength for each sublot, using cylinder splitting tensile strength determined for the sublot.

The following procedure shall be followed:

1. The laboratory beam specimens shall be made and cured in accordance with ASTM C 192 and the flexural strength of each specimen shall be determined in accordance with ASTM C 78.

2. The laboratory cylinder specimens shall be made and cured in accordance with ASTM C 192 and the splitting tensile strength of each specimen shall be determined in accordance with ASTM C 496/C 496M.

3. The field cylinder specimens shall be made and cured in accordance with ASTM C 31 and the splitting tensile strength of each specimen shall be determined at the specified age in accordance with ASTM C496/C 496M.

4. A correlation shall be developed between the flexural strength and the splitting tensile strength using 15 beam and cylinder specimens cast in the laboratory with no more than five companion cylinders and beams made from a single batch. After testing for and rejecting outliers in accordance with ASTM E 178, at a significance level of 5 percent, the flexural and splitting tensile strengths shall be averaged and the correlation shall be developed as follows:

   COR = Average Splitting Tensile Strength / Average Flexural Strength

5. For each sublot, the Contractor shall prepare, cure, and test three cylinders for splitting tensile strength. The average splitting tensile strength for the sublot shall be determined. The flexural strength for the sublot shall be determined by dividing the average splitting tensile strength for the lot by the correlation ratio, COR, as follows:

   Sublot Flexural Strength = Average Sublot Splitting Tensile Strength / COR

9.4.2.3 Strength Acceptance

The lot shall be accepted or rejected on the basis of Para. 12.1 – Basis for Pay Adjustment.

10.0 DEFICIENT AND DEFECTIVE PAVEMENT

10.1 Deficient Pavement

Deficient pavement evaluation and repair shall be at the Contractor’s expense.

10.1.1 Shallow Cracking

Shallow cracks, 2 inches or less in depth, shall be filled with free-flowing capillary methyl methacrylate installed by an installer skilled in such repairs. The penetration of the methyl methacrylate shall be checked by coring.

10.1.2 High Spots

High spots shall be ground. Grinding equipment that causes excessive raveling, aggregate fractures, spalls, or disturbance of the transverse and/or longitudinal joints shall not be permitted. Limits of grinding will be approved by the Engineer. Grinding shall remove the high spot deficiencies and shall not create surface conditions that will trap surface water runoff. Corrective work required shall be performed before thickness determinations, joint sealing, and grooving operations.

10.1.3 Sliver Spalls

Slabs with sliver spall deficiency shall be repaired by removing loose material in the affected length of the joint, cleaning the area, and applying liquid joint sealant in the affected area.

10.1.4 Joint Spalls

Slabs with joint spall deficiency shall be repaired as follows.

1. A boundary surrounding the spalled area shall be sawed using a concrete saw. The minimum width and length of the sawed area shall be 6 inches. The vertical saw cut shall be at least 1 inch outside the spalled area and to a depth of at least 2 inches. Saw cuts shall be straight lines forming rectangular areas. A light chipping hammer, maximum of 30 pounds, shall be used to remove all unsound concrete to a depth of 2 inches or to at least 1/2 inch below the depth of visually sound concrete, whichever is deeper. The area of concrete removal shall be tested for soundness to ensure that there is no loose material present. If any spall penetrates one-third the depth of the slab or more, the entire slab shall be removed and replaced as per Para. 10.2 – Defective Pavement.
2. A joint forming insert shall be used to re-form the existing joint. Care shall be taken to ensure that the spall repair material does not bridge the joint without a compressible insert in place along the joint
3. The cavity formed by removal of the unsound material shall be thoroughly cleaned with high-pressure water jets supplemented with compressed air to remove all loose material. The cleanliness of the cavity shall be maintained.
4. The clean cavity shall be filled with low slump concrete or a polymeric material. When required, a bonding agent shall be used to ensure a good bond between the existing concrete and the repair material. When required, the repaired patch shall be cured to prevent shrinkage or thermal cracking.
    a. When concrete is used as the repair material, it shall meet the requirements of Para. 6.1 – Concrete Requirements, the maximum aggregate size shall be 3/8 in.,

the concrete shall be consolidated and the patch shall be cured at least 72 hours before application of any construction traffic on the affected slab.

   b. When a polymeric material is used as a repair material, it shall be used in accordance with the manufacturer's recommendations. The polymeric material shall be compatible with the existing concrete and shall meet the strength requirement for concrete given in Para. 4.1 – Concrete Mixture Requirements.

5. After the patch has cured, the affected joint length shall be re-sealed. A reservoir for the joint sealant shall be sawed to the dimensions required for the original joint. The reservoir shall be thoroughly cleaned and sealed with the sealer specified for the joint.

10.2 Defective Pavement

Pavement that is deemed defective shall be removed and replaced as follows.

1. The affected slab shall be removed without damaging adjacent slabs. All saw cuts for the slab removal along the perimeter joints shall be perpendicular to the slab surface and shall be full-depth.
2. Slab removal shall be by the lift-out method. The slab to be removed may be cut into smaller sizes to facilitate removal.
3. Damaged base/subbase material shall be restored to the specified requirements for that material.
4. Load transfer at the perimeter joints shall be restored in accordance with Para. 7.7 - Dowel Bar Placement along Construction Joints. Dowel bar type, dimensions, and spacing shall be that specified for the construction joints for that pavement. When multiple adjacent slabs are removed, contraction joints shall be provided at the locations of the original intermediate joints and the load transfer type at the intermediate joints shall match the load transfer type of the original joints. If any of the perimeter joint is an expansion joint, the joint details shall match those of the original expansion joint.
5. Placement, consolidation, finishing, texturing and curing of the repair concrete shall be as specified for the original construction. Before concrete placement, the surfaces of all perimeter joint faces shall be cleaned of all loose material and contaminants and coated with a double application of curing compound as bond breaker.
6. All perimeter joints and the intermediate joints in the repair area shall be prepared for sealing and sealed in accordance with the joint sealing requirements.

11.0 MEASUREMENT

Portland cement concrete pavement shall be measured by the number of square yards of pavement as specified in-place, completed, and accepted.

12.0 PAYMENT

Payment for accepted concrete pavement shall be made at the contract unit price per square yard adjusted in accordance with Para. 12.1 – Pay Adjustment, subject to the following limitation:

1. The total project payment for concrete pavement shall not exceed **[ ]** percent of the product of the contract unit price and the total number of square yards of concrete pavement used in the accepted work.
2. Payment shall be full compensation for all labor, materials, tools, equipment, and incidentals required to complete the work as specified herein and as indicated on the plans, except for saw-cut grooving.

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The Engineer will specify a value ranging from 100 percent to 106 percent. When the total project payment for the concrete 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.

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12.1 Pay Adjustment

The pay factor for each individual lot shall be calculated in accordance with Table 1. A pay factor shall be calculated for both flexural strength and thickness.

TABLE 1 - PRICE ADJUSTMENT SCHEDULE [1]

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
96 – 100	106
91 – 95	PWL + 10
75 – 90	0.5PWL + 55
55 – 74	1.4PWL – 12
Below 55	Reject [2]

[1] Although it is theoretically possible to achieve a maximum 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 this section.

[2] The lot shall be removed and replaced as per Para. 10.2 – Deficient Pavement.. However, the Engineer may decide to allow the rejected lot to remain. In that case, when 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.

The lot pay factor shall be calculated as follows:

1. The higher of the two values when calculations for both flexural strength and thickness are 100 percent or higher.
2. The product of the two values when only one of the calculations for either flexural strength or thickness is 100 percent or higher.

3. The lower of the two values when calculations for both flexural strength and thickness are less than 100 percent.

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 this section. 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.

12.2 Pay Items

Item XXX – XX Portland Cement Concrete Pavement - per square yard.

APPENDIX A - TESTING REQUIREMENTS

ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 78	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C 88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 131	Standard Test Method for Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 173 /C 173M	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 174	Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C 192	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 496 /C 496M	Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens

ASTM C 535	Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 642	Standard Test Method for Density, Absorption, and Voids in Hardened Concrete
ASTM C 666	Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
ASTM C 1064 /1064M	Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C 1077	Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C 1567	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C 1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D 3665	Standard Practice for Random Sampling of Construction Materials
ASTM D 4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM E 178	Standard Practice for Dealing with Outlying Observations
ASTM E 965	Standard Test Method for Measuring Pavement Macrotexture Depth Using a Volumetric Technique.

APPENDIX B - MATERIAL REQUIREMENTS

AASHTO M 254	Corrosion Resistant Coated Dowel Bars
ASTM A 184	Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement

ASTM A 185	Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A 497	Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
ASTM A 615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A 704	Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
ASTM A 775 /A 775M	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 94 /C 94M	Standard Specification for Ready-Mixed Concrete
ASTM C 150	Standard Specification for Portland Cement
ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 494 /C 494M	Standard Specification for Chemical Admixtures for Concrete
ASTM C 595	Standard Specification for Blended Hydraulic Cements
ASTM C 618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C 881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 989	Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM C 1157	Standard Performance Specification for Hydraulic Cement
ASTM D 1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

ASTM D 1752	Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
TT-P-644 (Rev. D)	Federal Specification for Primer Coating, Alkyd, Corrosion-Inhibiting, Lead and Chromate Free, VOC-Compliant

END OF PROPOSED SPECIFICATION