PROPOSED SPECIFICATION FOR CONSTRUCTION OF AIRFIELD CONCRETE PAVEMENT

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ABSTRACT

The Standards for Specifying Construction of Airports, FAA Advisory Circular: AC 150/5370-10B incorporates Item P-501 – Portland Cement Concrete Pavement. Airfield 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. Item P-501 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

As part of a recent study, a proposed specification for construction of concrete airfield pavements has been developed for possible adoption by the FAA. The proposed specification places emphasis on the need to produce a durable end product, vis-à-vis, 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.

This paper presents highlights of the proposed specification.

INTRODUCTION

The Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5370-10, Standards for Specifying Construction of Airports, includes Item P-501 - Portland Cement Concrete Pavement (FAA [1]). As part of a study sponsored by the Innovative Pavement Research Foundation (IPRF), a proposed specification for construction of concrete airfield pavement has been developed as a possible replacement for Item P-501 (Tayabji and Anderson [2]). This paper presents the highlights of the proposed specification.

A fundamental assumption made during the preparation of plans and specifications for an airport pavement project is that a quality pavement performs well. Quality is an inherent property of a well-constructed pavement. Good materials and construction practices are vital for producing high quality and long lasting airfield concrete pavements. Even if a pavement is designed to the highest standards, it will not perform well if it is not constructed well. A pavement that is constructed well using good quality materials will require less maintenance and repairs over the years. As such, construction requirements and specification items need to be well defined, can be quantified, are measurable, and are not arbitrary. In addition, the project specifications need to have sufficient flexibility to allow for innovations by the contractor, as dictated by availability of materials and equipment and project size.

Pavement performance is significantly affected by the variability in the properties of key design features. While a certain amount of variability is unavoidable, excessive variability in the construction process can lead to random performance of pavements, as well as higher cost to the contractor due to corrective work required for early failures. Construction variability can be controlled by making effective use of quality control plans and process control testing.

A pavement performance item of significant interest to owners is elimination of foreign object damage (FOD). Airfield closures are primarily due to joint and crack spall repairs and cracked slab repairs, all of which pose significant cost and operational impacts. The reduction of FOD from spalls is a key durability related property addressed in the proposed specification. However, because there is no single objective or practical test that can be specified to achieve this durability requirement, a focus of the specification is to ensure that good materials and construction related practices are adhered to throughout the project.

The proposed specification incorporates the minimum prescriptive requirements to ensure a desired level of concrete pavement durability and a fair bidding environment, yet providing substantial flexibility to the contractor who best knows the interaction of the materials, equipment and construction processes. The proposed specification also aims to minimize construction of a marginally acceptable pavement by requiring that the contractor validate his construction processes by constructing a test section and by requiring a more demanding process control for the concrete delivered to the paver.

Primary assumptions of the proposed specification are:

1. The constructed concrete pavement will be durable regardless of concrete mix design and proportioning, placement and finishing, project size or climatic conditions.
2. The pavement should exhibit failure due to anticipated aircraft loadings over the design period and not due to material deficiencies that are a result of construction quality and soundness of materials used.

The Supplemental Report

A Supplemental Report (SR) for the proposed specification has 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 (Tayabji and Anderson [3]). The SR also discusses the impacts of deviations from specifications and provides guidance on recommended practices. The SR primarily provides explanatory notes and guidance on key specification items incorporated in the proposed specification and discusses the impacts of deviations from specifications and general recommended practices. As such, the SR addresses only items related directly to the proposed specification. The SR, by itself, is not a compendium on the best practices for specifying and constructing airport concrete pavements.

The SR follows the outline and the heading and sub-heading numbering system of the proposed specification. Explanatory notes and detailed discussions are provided, as necessary, for the appropriate sections of the proposed specification. Where no clarification is necessary, no notes are provided. As appropriate, additional external reference materials are also cited for in-depth discussion of specific items. The SR is not intended to provide a comprehensive discussion on studies related to items discussed in this report and it cannot replace sound engineering knowledge and successful local experience.

PROPOSED SPECIFICATION FORMAT

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. Item P-501 provides appropriate language to specify the items necessary to construct a durable airport concrete pavement conforming to the lines, grades, thickness, and typical cross sections shown on the plans.

Jointed plain concrete pavements are the most commonly used pavement type for airport applications and may be doweled or non-doweled at transverse joints. Jointed reinforced concrete pavements are not typically used for new airport pavement applications, except at fillet locations or for special-use applications. Continuously reinforced concrete pavements are typically constructed without any transverse joints.

The proposed specification incorporates requirements for the following:

1. End product
2. Submittals
3. Construction materials
4. Concrete mixture
5. Construction equipment
6. Weather management
7. Concrete paving (execution of work, including test section construction)
8. Contractor process control testing
9. End product acceptance testing
10. Treatment of deficient and defective product
11. Measurement
12. Payments

The key proposed items incorporated in the proposed specification are discussed next.

END PRODUCT REQUIREMENTS

The proposed specification relies heavily on end product requirements. A key requirement for the end product is that the concrete be durable, as a minimum, for the design life of the project, typically 20 plus years. However, there is not sufficient knowledge on how to clearly define and test for paving concrete durability. Therefore, by necessity, a limited amount of prescriptive requirements are incorporated in the proposed specification. It is an expectation that with time, the proposed specification will evolve into a true end product specification.

Some of the key end product requirements related to concrete as well as the as-constructed pavement are listed below.

1. Surface smoothness - Surface smoothness testing is required to assess the pavement roughness and considers impact to the aircraft traffic in terms of ride quality and the potential for hydroplaning to develop as a result of bird-baths.

2. Vertical deviations from established alignment of the pavement edge - This requirement ensures compliance with the plan requirements for alignment.

3. Free edge slump - Edge slump is a critical item for airport concrete pavements. Excessive edge slump indicates that the contractor's process is out of control and the in-place concrete can be expected to exhibit early durability failure. Excessive edge slump can also contribute to joint distress and higher potential for hydroplaning.

4. Dowel bar alignment – Dowels need to be placed within specified tolerances. Dowel misalignment can have significant impact on pavement performance, in terms of slab cracking, joint spalling and poor load transfer at joints.

5. Flexural strength - This requirement ensures compliance with the design requirements for the pavement. The concrete mixture is required to attain the specified flexural strength at the specified age. The design of the concrete pavement should be based upon a concrete flexural strength of 600 to 650 psi and that the specified strength at 28 days may be upto 5% less than the design strength for production paving as these pavements are typically not opened to traffic for at least 60 days after concrete placement.

6. Slab thickness - This requirement ensures compliance with the design considerations for the pavement.

Other End-Product Related Requirements

The contractor is required to meet certain additional requirements to assure the engineer and the owner agency that the materials and processes used in the construction of the concrete pavement meet the specified requirements. These requirements are necessary because in most cases use of marginal materials or processes may not result in immediate failures, but may affect long-term durability and development of distresses much earlier than expected.

End Product Responsibility

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

The engineer determines 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 in the proposed specification. If the engineer finds the materials furnished, work performed, or the finished product are not in conformity with the plans and specifications and have resulted in an unacceptable finished product, the affected work or materials is required to be removed and replaced or otherwise corrected by and at the expense of the contractor in accordance with the engineer's directions.

SUBMITTALS

Submittals are required from the contractor to assess the level of conformance with the project specifications. The submittals list is always a challenge for both the contractor and the engineer. The contractor may not fully understand what he needs to provide to the engineer and many engineers may not fully understand what to specify and how to review many of the submittals, including the submittal for the concrete mixture proportions.

The submittals to be provided to the engineer may include information provided by equipment makers, material suppliers, State DOT certification, and contractor sponsored material test data. Three categories of submittals are required, as follows:

1. Pre-construction submittals – These submittals are related to qualification of materials, concrete mixtures and equipment. These submittals are required to be submitted to the engineer before concrete placement activities can begin.

2. Process control submittals – These submittals are related to the contractor's process control to ensure that quality controls are integrated during each day of production paving.

3. Acceptance Testing Submittals – These submittals are related to the required acceptance testing to ensure that the owner is provided with a product that has been specified.

Some key submittals related issues are listed below:

1. Cement supplies need to be secured to ensure supply during the peak construction season. If the cement source is changed, additional mix design and compatibility testing is required. It is advisable to pre-qualify mixture designs using different cementitious materials so that if a substitution needs to be made, the mix design data are already available and the new materials can be accommodated without delay.

2. Typically, about 60 to 90 days lead-time is available from contract award to start of work, so aggregate acceptance needs to be done within that time or before the award.
3. The materials related submittals need to be submitted for the engineer's review before new materials are used for the work.
4. For aggregate and concrete mixtures to be used on the project, the pre-construction certifications, except for the reactive aggregate mitigation plan, developed using materials sampled not more than 180 days before the start of concrete placement are acceptable. The certification shall include flexural versus splitting tensile strength correlation data, if applicable, for the concrete mixture to be used for the project.
5. Cement and supplementary cementing material mill certification need to be submitted for each truckload of the material for the engineer's review within 24 hours of material delivery.

MATERIALS

The materials requirements can be categorized into two categories, as follows:

1. Concrete materials related requirements
2. Non-concrete materials requirements.

No significant changes are proposed in the non-concrete materials requirements.

Some significant new items in the proposed specification relate to aggregates. Aggregates are a key component of concrete and can affect the properties of fresh and hardened concrete. Aggregate selection should allow for maximizing the volume of aggregate in the concrete mixture in order to minimize the volume of cementitious paste without compromising the workability, durability and strength of the concrete mixture. These items include the following:

Maximum Aggregate Size

Selection of maximum aggregate size is left to the contractor. Exceptions to this include the following cases:

1. Use of smaller maximum size aggregate for D-cracking regions. It should be noted that the use of smaller maximum aggregate size alone does not prevent D-cracking, and many state agencies have criteria for D-cracking other than maximum aggregate size. The Engineer may also require aggregate testing in accordance with ASTM C 666 to verify freeze-thaw resistance of the selected aggregates for use in D-cracking regions
2. Owner-specific criteria.

Aggregate Gradation

The proposed specification mandates use of combined aggregate gradation that produces a dense aggregate matrix that can be easily placed, consolidated and finished. Concrete mixtures produced with a combined aggregate gradation that produces a dense aggregate matrix tend to:

1. Reduce the water demand
2. Reduce the cementitious material demand
3. Reduce the shrinkage potential
4. Improved workability
5. Require minimal finishing
6. Consolidate without segregation
7. Enhance strength and long-term performance.

There is no limit on the number of aggregates that may be used. In many instances, the mixture proportioning studies will indicate a need for aggregates in the 3/8 to No. 4 range to improve the workability of the mixture. Typically, contractors use three aggregates to produce a dense graded aggregate. The combined gradation is evaluated using the Workability Factor (WF) and Coarseness Factor (CF) Method procedure, based on the work reported by Shilstone and Shilstone [4], to determine if a gradation meets the optimized combined aggregate gradation criterion. 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, are deemed to have met the requirements of an optimized combined aggregate gradation when the following criterion is satisfied:

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

In accordance with the Shilstone method, materials with WF and CF within parallelogram ABCD of Figure 1 are considered as meeting the criteria for optimized combined aggregate gradation. The diagonal control line defines a region where combined rounded or cubical crushed stone and well-graded natural sand are in balance. However, such mixtures have limited application, as the aggregate gradation must be well controlled. These mixtures are often excellent for bucket placed concrete in large footings. Mixtures represented by plots above the control line identify mixtures with increasing amounts of fine aggregate. Those below the control line generally contain an over abundance of coarse particles and are not desirable for concrete paving.

Aggregate Reactivity

Alkali-silica reaction (ASR) is a deleterious chemical reaction between the reactive silica constituents in the aggregates and alkali hydroxides in the concrete. The product of this reaction often results in significant expansion and cracking of the concrete. In addition, deicing chemicals can also create a reactivity problem. The research in this area is on-going at the time of this paper (late 2006). The proposed specification provides test requirements based on current practices for airports using deicer chemicals (potassium acetate) and for airports not using deicer chemicals.

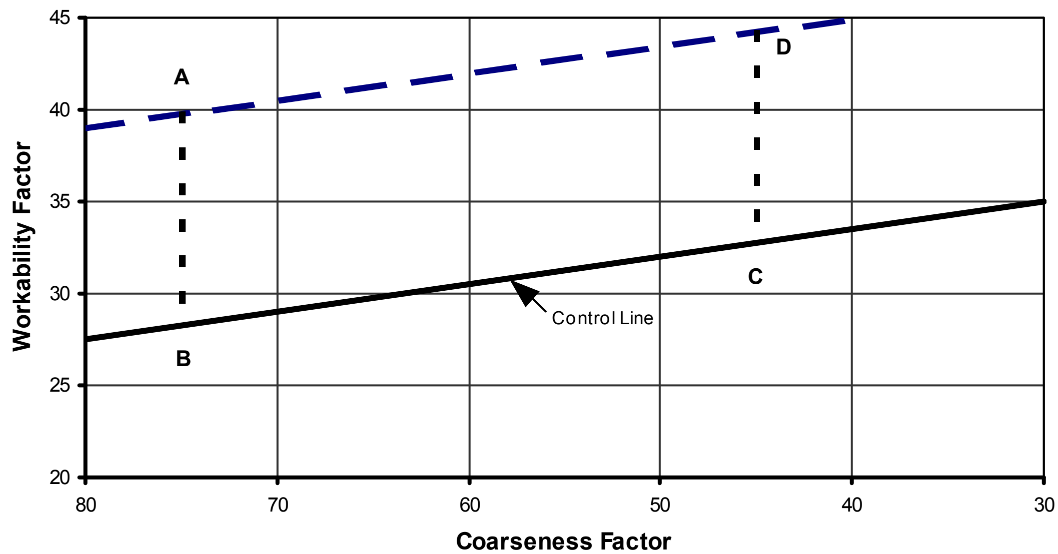

Figure 1. Aggregate Constructability Chart

CONCRETE MIXTURE

The concrete mixture is the most critical element of the pavement. As such the concrete requirements need to be well-established. The proposed specification does not mandate a mixture proportioning procedure.

Concrete Mixture Requirements

The proposed specification requires the concrete mixtures to meet the requirements related to the following items:

Concrete Strength

The engineer establishes the concrete strength. A key consideration is that the concrete strength specified can be reasonably attained, considering locally available materials and economical considerations. FAA's AC 150/5320-6D (pavement design procedure) recommends that the design flexural strength used to determine the concrete slab thickness should be about 600 to 650 psi at time of opening to aircraft traffic, which is typically 60 to 90 days after concrete placement. Concrete strength for construction acceptance, however, is typically specified in terms of 28-day strength. This provides an additional factor of safety and ensures that structural performance of the concrete pavement will meet the anticipated demands.

Minimum Cementitious-Material Content

The minimum cementitious materials content required for durability is greater than the amount required for strength and workability. Although it is possible to optimize a mix to achieve the lowest possible cementitious materials content and still achieve strength requirements, a minimum cementitious materials content is required to ensure that long-term durability of concrete is not compromised.

In fresh concrete, minimum cement content is required to develop sufficient paste to coat the aggregates and thus make the mix workable. The minimum amount of paste required to fill all voids will be dependant on aggregate grading (i.e. the amount of space between aggregate particles). In hardened concrete, minimum cement content is required to ensure that there is sufficient paste to coat all of the aggregate particles, and to fill all the spaces between them. . Both strength and potential durability decrease with increasing void content.

In mild and moderate exposure regions, 470 pounds per cubic yard is acceptable, and 517 pounds per cubic yard is acceptable in severe exposure regions, based on industry-accepted requirements. For most projects, use of the combined aggregate gradation will allow the strength requirements to be readily achieved with these minimum cementitious materials contents.

Water-to-Cementitious Materials Ratio

The optimum water to cementitious materials (w/cm) ratio is the minimum ratio that satisfies the need for concrete strength and durability. Very low w/cm ratios are not recommended as it may also lead to concrete durability issues. Alternatively, a maximum ratio is specified to ensure that the cementitious materials use is optimized with respect to achieving the desired strength levels, to limit drying shrinkage, and to minimize the amount of capillary porosity in the hardened concrete. The allowable w/cm ratio is 0.38 to 0.45, with a maximum ratio of 0.50 allowed in moderate/mild/negligible weathering regions as defined by ASTM C 33.

Supplementary Cementing Materials

The proposed specification limits the use of the supplementary cementing materials as follows:

1. Fly ash – not to exceed 25% of total cementitious content
2. Slag – not to exceed 50% of total cementitious content
3. If both fly ash and slag are used, the total supplementary cementing material shall not exceed 50% of total cementitious content
4. Total supplementary cementitious content shall not exceed 50% for mixtures using C 595 or C 1157 cements.
5. In case of reactive aggregates, the use of the supplementary cementing material will be governed by the contractor's reactive aggregate mitigation plan.

Air Content

A certain level of entrained air is necessary to ensure protection in freezing environments. The target percentage of air in the mix is based upon the exposure condition and maximum aggregate size in accordance with ASTM C94/C 94M, unless local experience suggests otherwise.

Concrete Mixture Proportions

Mixture proportioning addresses the combination of the individual concrete making materials to produce a concrete mixture that will meet the project requirements discussed in the previous section. The contractor may use any method to develop the concrete mixture. However, the proposed specification mandates use of a combined aggregate gradation that results in a dense concrete matrix. There is no limit to the number of mixtures a contractor may develop and submit for the engineer's review. Concrete mixtures need to be developed for:

1. Each expected method of concrete placement.
2. The anticipated ambient temperatures. Concrete that can be placed at one temperature may not be workable at another.
3. Specific construction requirements – normal paving versus fast-track paving, anticipated changes in material supply, etc.

The laboratory mixture proportioning is only a starting point and the contractor should verify his mixture at the test section and adjust the individual proportions within the allowed limits to ensure that the concrete mixture is workable for his paving equipment. There is no concern with strength or durability if the mixture proportions are adjusted within the allowed limits.

Strength Correlation Data

The proposed specification allows the contractor the option of using flexural strength or splitting tensile strength testing to determine concrete flexural strength at the specified age. If the contractor elects to use splitting tensile strength testing, a one-point correlation between the flexural strength and the splitting tensile strength needs to be developed by testing 15 beams and 15 cylinders at the specified age. The one-point correlation should be developed as soon as the final mixture proportions have been established on the basis of the laboratory testing.

EQUIPMENT

The Contractor is required to furnish all equipment and tools necessary for handling materials and performing all parts of the concrete pavement construction. Most equipment related requirements are similar to current requirements, except the following.

Concrete Batching Plant

Concrete is a manufactured product, the quality and uniformity of which depend upon the control exercised over its manufacture. The concrete batch plant needs to be in good condition, operate reliably, and produce acceptable concrete uniformly from batch to batch. NRMCA QC3 document is the recommended standard and is to be used for projects where it is anticipated a batch plant will be dedicated to the project, either on or off site.

Concrete mixer uniformity testing is required for central mix plants and truck mixers before production of the project concrete. Uniformity tests are to be conducted for all batch plants that are moved. Criteria for mixer uniformity is in accordance with ASTM C 94/C 94M.

Paving Equipment

No specific details related to the paving equipment are specified. The paving equipment should be capable of placing and consolidating the concrete uniformly across the width of placement. The equipment should shape the concrete to the specified cross section. Paver selection is at the option of the contractor. However, the paving equipment is required to be equipped with internal vibrators that are monitored with a vibrator monitoring device that indicates the frequency of each installed vibrator.

WEATHER MANAGEMENT

For larger paving projects, the Contractor is required to submit 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 is to be submitted before start of concrete paving. The following are the key weather related requirements:

1. Maximum allowable concrete temperature after depositing in front of the paving equipment is 95 degrees F.
2. Concrete should not be placed when the temperature of the air at the site is 40 degrees F and falling or the surfaces on which the concrete is to be placed is less than 32 degrees F.
3. In cold weather, 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.
4. Concrete should not be placed when rain conditions appear imminent. The Contractor is required to maintain on-site sufficient waterproof material and means to rapidly place it over all freshly placed concrete surfaces that may be damaged by rain.

EXECUTION

The contractor is required to validate his concrete production, placement, and finishing operations by means of a test section. The test section is a critical element to enable the contractor to adapt the concrete mixture and paving equipment to the site conditions, and demonstrate to the owner/engineer that the acceptance criteria can be achieved using his materials and his processes. A test section is not required for small projects that involve less than about 2,000 cubic yards of concrete production.

Test Section

The test section is to be constructed on the first day of paving with a maximum placement of one lot for the selected paving method. The test section width and thickness should be most representative of the production paving area. Ideally, a non-critical area that is also representative of the majority of paving should be selected as the site for the test section. It is expected that some adjustments may be made to the laboratory based concrete mixture proportions as well as some of the contractor's operations to achieve the desired end products.

The acceptance criteria for the test section are the same as for production paving; however, partial or conditional acceptance is not allowed because the contractor must demonstrate control over all materials and equipment. A project cannot begin without acceptable control of the processes as demonstrated at the test section. A period of time to evaluate the test section and to submit the test section data to the engineer is necessary. This evaluation period, about 24 hours, is mandatory and cannot be waived.

Removal of unacceptable portions of the test section is determined by the engineer. Partial payment and corrective action methods can be utilized. If the total length of paving on the first day does not produce an acceptable test section of the minimum continuous length/volume specified, then another test section shall be built. The mixture proportions determined from the test section become the approved proportions for the project.

Production Paving Adjustments to the Concrete Mixture Proportions

Shortages of cement or other concrete-making ingredients may occur during the construction season. If any changes in type, source, or brand of cementitious material, or aggregate source need to be made, new mixture proportions will need to be developed by the contractor and approved by the engineer. Certain minor adjustments to the concrete mixture proportions may be necessary due to changes in the weather and to maintain the required workability and air content. Allowable adjustments in the mixture proportions are given in the specification and are listed below:

1. Individual aggregate proportions may be adjusted as necessary. However, the combined aggregate gradation may be adjusted only within approved limits.

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.

Overall Concrete Placement Requirements

The concrete should be placed, consolidated, finished, and cured to meet the requirements related to product acceptance testing. Hand-finishing operations behind the paver are to be kept to a minimum to correct only minor surface defects. Concrete shall be continuously protected against loss of moisture for at least 72 hours after the completion of finishing operations. All processes used during production paving should be equal to or better than the processes validated during the test section construction.

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. 450 psi, or
   b. Equal to or more than the Zero Fatigue Stress. The Zero Fatigue Stress is the larger value of 300 psi and 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. These procedures may include flexural or splitting tensile strength or maturity testing.

Thus, the in-place flexural strength at the time of opening to construction traffic needs to be at least 300 psi, but is not required to be over 450 psi.

PROCESS CONTROL

The Contractor is required to perform all tests necessary to monitor the concrete production and concrete pavement construction processes to produce a pavement that meets the specifications. The contractor is required to submit a Quality Control Plan that addresses the contractor's overall quality processes and testing requirements for process control. The plan should 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 plan shall also detail the corrective actions that will be taken to bring the processes under control. The contractor is required to perform, as a minimum, the inspection and tests described below:

1. Accuracy of Plant Batching - in accordance with NRMCA QC 3 procedure
2. Aggregate Quality – deleterious substances and flat and elongated pieces, as per ASTM C33
3. Combined Aggregate Gradation -, as defined in the specification
4. Air Content, if applicable - as per ASTM C94
5. Concrete Temperature - as defined in the specification
6. Hand Finishing at Edges - as defined in the specification

The Contractor is required to make provisions to allow the engineer to observe all inspection and testing performed by the contractor to verify the contractor's procedures.

ACCEPTANCE TESTING

Acceptance testing is performed to determine compliance with the end product requirements of the specifications. The proposed specification incorporates two categories of acceptance testing –engineer performed acceptance testing and contractor performed acceptance testing. The recommended lot size for production paving is 2,000 cy, with each lot divided into five equal sublots. The proposed specification provides guidance for considering partial lots and sublots and for designating lots for smaller projects.

Engineer Performed Acceptance Testing

The engineer is required to perform the following tests:

1. Straightedge – using a 16 ft straightedge. Areas in a slab showing 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 is considered deficient and marked for review by the Engineer. Slabs with low spots that impair surface drainage are required to be removed and replaced at the contractor's expense. It should be noted that 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.
2. Grade – vertical deviations from plan. The engineer evaluates areas out of tolerance for severity of non-compliance and determines if these areas are defective. Slabs with out of tolerance grade that impair surface drainage are required be removed and replaced at the Contractor's expense.
3. Edge Slump - Not more than 15 percent of the total free edge of each slab panel shall have an edge slump exceeding 1/4 inch, and none of the free edge of the pavement shall have an edge slump exceeding 3/8 inch. Slab panels with excessive edge slump shall be deemed defective.

4. Cracking - Slab panels exhibiting cracking are considered defective and are required to be mitigated as directed by the engineer. Slab panels exhibiting shallow cracking are considered deficient, not defective. Plastic shrinkage cracking is cracking that is 2 inches or less in depth and occurs due to excessive moisture loss while the concrete is still in a plastic state. Plastic shrinkage cracking is treated by using free-flowing capillary epoxy application installed by an installer skilled in epoxy repairs.
5. Sliver and Joint Spalls – it is permissible to repair minor amounts of sliver and joint spalls. However, slab panels exhibiting excessive amounts of sliver and joint spalls are considered defective and are required to be mitigated as directed by the engineer.
6. 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 need to be placed within 1 inch of slab mid-depth and spaced within 1 inch of planned location along the joint. For longitudinal construction joints, the dowel bars need to be embedded one-half the dowel length plus or minus 1 inch. For transverse and longitudinal contraction joints, the dowel center point is to be located within 2 inches of the joint sawcut.

Contractor Performed Acceptance Testing

The contractor is required to perform the following tests:

1. Thickness - Acceptance of each lot of in-place pavement is based on percent within limits (PWL0 considerations. Slab thickness is determined for each sublot at locations agreed upon with Engineer. Thickness is determined using cores or other methods approved by the engineer.
2. Strength - Acceptance of each lot of in-place pavement for concrete flexural strength is based on PWL. Concrete strength is determined using beams or cylinders. The contractor shall elect one method for strength testing and uses this method to determine flexural strength, once production paving has started. The proposed specification incorporates a procedure that allows determination of concrete flexural strength from cylinder-based splitting tensile strength.

The Contractor is required to make provisions to allow the engineer to observe all acceptance testing performed by the contractor to verify the contractor's procedures.

TREATMENT OF DEFICIENT AND DEFECTIVE PAVEMENT

Deficient pavements are areas that can be easily repaired without impacting pavement's performance. On the other hand, defective pavements are areas that can impact the pavement's performance and need to be mitigated based on a review by the engineer. The mitigation may involve slab removal and replacement or pay adjustment to reflect the marginal value of the pavement.

The following items result in slab panels being classified as deficient:

1. Shallow cracking
2. High spots
3. Minor amounts of sliver and joint spalls.

The following items result in slab panels being classified as defective:

1. Cracking, other than shallow cracking
2. Excessive amounts of sliver and joint spalls
3. Low spots impacting surface drainage
4. Excessive edge slump
5. Excessive dowel misalignment
6. Slab thickness with PWL < 55%
7. Concrete strength with PWL < 55%

The proposed specifications provide directions for treating deficient and defective pavement slab panels.

SUMMARY

This paper presents the highlights of a proposed specification for construction of airfield concrete pavements. The focus of the specification is on obtaining a durable end product by minimizing construction and materials related variability and by minimizing the placement of concrete of marginal quality. The proposed specification is based as much as possible on end product requirements. It safeguards the owners desire to obtain a low maintenance pavement facility that is free of FOD while ensuring that the contractor has sufficient flexibility to consider availability of materials and innovative construction processes. A companion supplemental report provides the basis for the key requirements of the proposed specification. The proposed specification underwent a web-based review by industry and technical association user groups during the summer of 2006. The feedback by the user groups has been incorporated in the proposed specification.

The final report of the study reported here contains recommendation of the IPRF to the FAA and any decision to adopt all or part of the recommendations rests with the FAA.

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