Engineering Brief # 34A

May 13, 2002

Subject: **INFORMATION** : Engineering Brief No. 34A,
"Referee Testing of Hardened Portland Cement
Concrete Pavement--Percent Within Limits Revision"

From: Manager, Airport Engineering Division, AAS-100

To: All Regions
ATTN: Airports Division Managers

Engineering Brief No. 34A, "Referee Testing of Hardened Portland Cement Concrete Pavement--Percent Within Limits Revision", copy attached, suggests a process to use to substantiate the strength of portland cement concrete pavement when the results of normal flexural strength acceptance tests are suspect and when the acceptance criteria is based on percentage of materials within specification limits (PWL).

The conduct of referee tests should not be done on a carte-blanche basis. Referee testing should only be considered when there is evidence to confirm that the standard flexural strength test results are not representative of the in-place material. The suggested method is a revision to Engineering Brief No. 34, which was originally used by the U. S. Navy, and subsequently by the Federal Aviation Administration (FAA). Engineering Brief 34 as previously published is now cancelled.

Devising a plan for referee testing is not the responsibility of FAA. However, any plan must be approved by the FAA to establish whether the results of the referee testing may be used to determine pay factors for the material in question when Airport Improvement Program rules apply. The program to establish all of the criteria for random sampling, testing, and acceptance should be developed and accepted by all parties prior to physical sampling and testing.

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Attachment

ENGINEERING BRIEF NO. 34A

REFEREE TESTING OF HARDENED
PORTLAND CEMENT CONCRETE PAVEMENT
PERCENT WITHIN SPECIFICATION LIMITS (PWL) REVISION

Purpose

The purpose of this Engineering Brief is to present a method of testing hardened portland cement concrete pavement when doubt exists as to the validity of the standard flexural strength test results and when the acceptance criteria is based on percentage of materials within specification limits (PWL). The method does not purport to give an exact strength, but rather, a strength that is consistent with FAA design and acceptance assumptions. This method is not to be routinely used in lieu of standard flexural strength acceptance testing.

Background

The standard test for acceptance of portland cement concrete strength is ASTM C 78, Flexural Strength of Concrete (using simple beam with third-point loading). Item P-5Ol, Portland Cement Concrete Pavement, provides guidance on the interpretation of test results and pay factors for flexural strength acceptance testing. Sometimes disputes arise as to the validity of the flexural strength test results. Improper specimen preparation or curing, mishandling of test beams, improper testing techniques, uncalibrated testing machines, etc. are often cited as reasons for questioning the flexural strength test results.

Process

The process described below is suggested and can be used to establish the flexural strength of hardened concrete with reasonable confidence and applied to the PWL acceptance criteria for portland cement concrete pavement. The process contains information regarding test method, testing and acceptance program, and application. The process assumes that acceptance testing, presumed to reflect the in-situ product, has been completed prior to the possibility of referee testing.

1. Test Method. When it can be established that the validity of flexural acceptance test results is not sufficient, the hardened concrete may be cored, moisture conditioned, and tested to determine the splitting tensile strength in accordance with ASTM C 42, Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

The tensile split test is recommended as a referee test since the failure mode is somewhat similar to flexural failure. A correlation between compressive strength and flexural strength could be used, however it is felt that the difference in the failure modes between compressive and flexural failure make compression testing less attractive as a referee test. ASTM C 42 is recommended because it provides for proper moisture conditioning prior to testing in accordance with the applicable provisions of ASTM C 496, Splitting Tensile Strength of Cylindrical Concrete Specimens.

2. Testing and Acceptance Program. Before initiating physical sampling and testing, the scope of the testing program must be developed and

accepted by all involved parties and approved by the FAA. This program becomes a binding agreement between the involved parties and should include the following items:

a. Basis for Retesting. The project contract documents provide an industry recognized procedure of acceptance testing. The acceptance testing procedure contains provisions and safeguards that customarily produce results representative of the product placed in the field. If a party to the contract can provide concise, persuasive evidence that the acceptance testing procedures did not produce results indicative of the field product, such evidence would be the basis for referee testing.

Prior to retesting, it is important and required to determine why the original acceptance testing is incorrect. The reason the original tests are incorrect can greatly influence the method and scope of the referee testing program. There are hypothesis tests to determine if two sets of data represent the same population (F-test) and if the two sets of data represent the same average level of production (t-test). If the test data from acceptable lots and from questioned lots are compared using these hypothesis tests, then a 5 percent significance level is recommended.

b. Cost for Referee Testing. Only the original acceptance testing is eligible as a project cost. In the event referee tests are necessary, the additional cost for establishment of the referee testing program, the physical sampling and testing, and concrete repair at sampling locations, are not eligible for Federal reimbursement. The cost associated with referee testing will usually become the responsibility of the party causing the need for additional testing. It is recommended that the party(ies) responsible for the costs be identified in the referee testing program. Regardless, no cost associated with referee testing is eligible for Federal reimbursement.

c. Test Methods. Since they are not addressed in the official project documentation, all necessary sampling and testing procedures need to be identified. Test methods for items such as specimen extraction, handling, transporting, testing, etc. must be identified prior to physical testing. ASTM D 3665, Random Sampling of Construction Materials, and ASTM C 42, Obtaining and Testing Drilled Cores and Sawed Beams of Concrete, should be identified at a minimum.

d. Testing Frequencies, Sampling, and Coring. In most cases, rejection of the standard flexural test results leaves little or no information available for the lot or sublot in question. As a result, referee testing must reproduce the statistical sampling program originally specified in the project documents. The required number of referee test specimens is often heavily debated due to cost of testing, pavement closure, and damage to the pavement. As a general rule, the sampling and test frequencies established in the original document should be maintained. Sampling locations should be determined in accordance with ASTM D 3665.

Only one core sample should be drilled from each sublot in accordance with ASTM C 42.

It may be possible to obtain more than one test specimen from a core. No more than two specimens per core, meeting the minimum height requirements

of ASTM C 42, should be tested, and the average of the two tests should be used as the strength result.

Core diameter should conform to the following:

For plain concrete, core diameter should be 5.75 inches +/- 0.25 inches.

For reinforced concrete, core diameter may be reduced to 4 inches +0.25 / -0.0 inches, to avoid inclusion of the reinforcement steel in the core samples.

e. Estimating Factors. . The recommended correlation between splitting tensile strength and flexural strength is given in Equation 1 as follows

Flexural strength (psi.) = 1.02 x Splitting tensile strength (psi.) + 117 psi. Eqn. 1

Equation 1 can be used with 85 percent confidence that the estimated flexural strength is at least as strong as the strength derived from the original regression analysis detailed in CONCRETE STRENGTH RELATIONSHIPS, Miscellaneous Report Number S-74-30, published by the Army Engineer Waterways Experiment Station, December 1974.

f. Factors Affecting the Strength of Samples. The expression in paragraph 2e above, does not address the complication that various factors can affect the strength of the samples. Items such as age of the specimen, size of the specimen, fly ash or slag additives that result in later age strength gains, may require numerical adjustments to the physical results. There are several possible schemes to estimate the strength of older specimens with the age required by project specifications. An accepted industry standard may be applied to adjust the samples or the program may include additional testing of previously unquestioned concrete for the project to provide a relative comparison.

As an alternate to a detailed investigation into the factors affecting the later age strength gain, a method is presented below that applies a variable confidence interval to the original regression over a time period. Table 1 below varies the confidence interval from 85 percent to 95 percent over a seven month period. The table shows three age-strength intervals.

TABLE 1 FLEXURAL STRENGTH ESTIMATE - AGE AND CONFIDENCE INTERVAL

In-Place Concrete Age (in days)	Flexural Strength (MR) Estimate where T = Splitting Tensile Strength from ASTM C 496	Confidence Interval (percent)
up to 60 days	MR (psi.) = 1.02 x T + 117	85 percent
60 to 276 days	MR (psi.) = 1.02 x T + 117 - 0.25 x (Age - 60)	85 to 95 percent
over 276 days	MR (psi.) = 1.02 x T + 63	95 percent

Note: For a given strength, the estimates assumes a gradual 54 psi. strength gain after the first 60 days.

The three intervals assume a gradual strength gain with time after initial curing. For the time period between the 28-day strength and 60 days in place, no increase in the confidence interval is applied and no strength increase is applied. After 60 days in place and up to nine months in place, the confidence interval is gradually increased from 85 percent to 95 percent. After nine months in place, no additional strength increase is applied. For example, if a pavement has a splitting tensile strength of 523 psi. at 60 days, it correlates to 650 psi flexural strength. At 150 days, the above estimates assumes a splitting tensile strength gain of 22.5 psi higher and the 545.6 psi. strength at 150 days would continue to correlate to a flexural strength of 650 psi. at 60 days At nine months and beyond, the total splitting tensile strength gain assumed by the expression is 54 psi.

The flexural strengths derived using the agreed to correlation expression may be used in accordance with pay adjustment schedule guidance contained in the project documents, with no additional adjustments, in lieu of the original questionable flexural strength tests for projects evaluated using PWL concepts

g. Combining Referee Tests with Original Flexural Tests. It is not advisable to combine referee tests with the original flexural tests since different test methods are used.

3. Application. The conduct of referee tests should not be done on a carte-blanche basis. Reasonable doubt as to the validity of the normal flexural strength acceptance tests must be established. Normally, it is the responsibility of the engineer, testing lab or contractor to propose a method of referee testing to either prove or disprove the flexural strength results.

Originally Signed By
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