Concrete Property Test

Air Entrainment 3-3: Air-Void Analyzer (AVA)

National Concrete Pavement Technology Center
www.cptechcenter.org

Purpose – Why Do This Test?

Freeze-thaw resistance of concrete is primarily controlled by an air-void system with closely spaced small bubbles. The air-void analyzer provides a method of measuring the spacing factor in fresh concrete, rather than waiting for microscopical analysis of hardened concrete. A sample of mortar is taken from the concrete after it has been through the paver and tested immediately, with a result obtained in about 30 minutes. The AVA test should be used for quality control, not acceptance.

Principle – What is the Theory?

Gently stirring a sample of fresh concrete mortar releases the air bubbles through a viscous fluid and then through a column of water. The air bubbles are captured under a submerged bowl that is connected to a scale. As the air bubbles collect, the buoyancy (mass) of the bowl is recorded over time. The measurement of the buoyancy of different-sized bubbles (over time) is a function of Stoke's Law (larger bubbles rise faster than smaller bubbles).

Test Procedure – How is the Test Run?

A sample of fresh concrete mortar is taken from the slab behind the paver using a vibrating cage attached to a hand drill. A 20-cc portion of the mortar sample is injected into the instrument, which then gently stirs it to release the air bubbles into the fluid.

The measurement continues for 25 minutes or until the weight of the bowl remains unchanged for 3 minutes.

Software then processes the scale readings that were taken over time and, using an algorithm, calculates the air-void spacing factor and bubble size.

An AASHTO standard is currently being developed for the AVA.

Test Apparatus (figure 1)

- Portable drill with vibrating cage for obtaining mortar sample.
- Air-void analyzer (AVA) with all supplies, cables, etc.
- Personal computer with AVA software.

Figure 1. AVA setup in a portable lab and AVA sampling equipment

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Test Method – Refer to Applicable AASTHO/ ASTM Standards and CP Tech Center's AVA Hyperdocument for Comprehensive Guidance

1. Obtain a sample of fresh mortar behind the paver.
2. Using a syringe, extract 20 cc of mortar from the sample.
3. Eject the 20-cc sample from the syringe and gently agitate it for 30 seconds.
4. The bubbles are released from the mortar sample and, over time, rise through the separation liquid and through a column of water.
5. As the bubbles rise, they are collected underneath a submerged bowl.
6. The buoyancy (mass) of the submerged bowl is measured over time as the bubbles are collected.
7. The test is concluded when the mass of the submerged bowl remains constant for 3 minutes or at the end of 25 minutes, whichever occurs first.
8. The computer and software collect and analyze the data from the scale, which is part of the AVA.

Output – How Do I Interpret the Results?

Software provided with the AVA produces tabular and graphical reports. Values are reported for the following:

- Spacing factor: Values less than 0.01 in. are desirable, although values less than 0.15 in. are commonly considered acceptable.
- Specific surface (bubble size): Values greater than 600 in^{-1} are desirable.
- Air-void content of paste.
- Air-void content of concrete.

Test results should be plotted graphically (figures 2 and 3) and monitored to assure air-void properties are within suggested limits.

Construction Issues – What Should I Look For?

AVA testing should be implemented as a quality control tool for Level A projects of a critical nature that are located in wet-freeze climates. Even though correlations between conventional air-void testing (ASTM C 457) and image analysis techniques are not reliable, the AVA provides the only way to obtain feedback regarding the air-void properties of a fresh concrete sample. Field results can be obtained within one hour of concrete placement.

Comparisons between the AVA and ASTM C 457 test results on the same concrete reveal that the AVA test results are conservative. Thus, a marginal spacing factor measured with the AVA may be adequate in certain cases. Because of this undefined bias, the AVA should not currently be used as a test method for acceptance. Future research and improvements may make this possible. Best practice for AVA use as a quality control tool include monitoring the specific surface and spacing factor test results for trends and changes during production. Materials and construction processes should be monitored closely whenever AVA spacing factor test results exceed 0.0150 in.

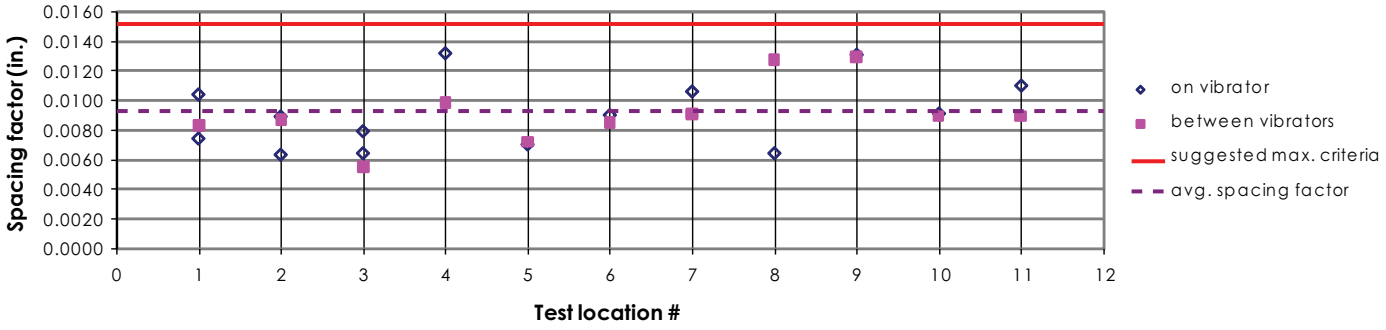

Figure 2. Spacing factor results (IA MCO demonstration project)

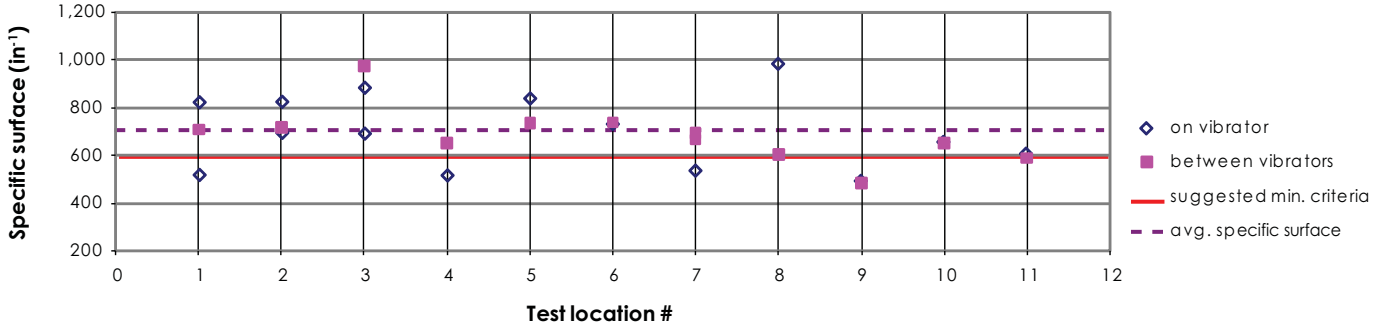

Figure 3. Specific surface results (IA MCO demonstration project)

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This test summary is one of a set of summaries originally published in chapter 7 of the *Testing Guide for Implementing Concrete Paving Quality Control Procedures* (Fick, G., Iowa State University, Ames, Iowa, 2008). The testing guide is a product of a 17-state, Federal Highway Administration pooled-fund project, Material and Construction Optimization for Prevention of Premature Pavement Distress in PCC Pavements, TPF-5(066). The project was managed by the National Concrete Pavement Technology Center at Iowa State University.