Priority, Market-Ready Technologies and Innovations

PAVEMENT & MATERIALS

Air Void Analyzer (AVA)

Problem: Freeze-thaw cycles cause premature concrete deterioration

Premature deterioration of cement-based concrete structures puts a tremendous financial burden on many transportation agencies. Moreover, badly deteriorated concrete in pavements, bridges, and other highway structures adversely affects economic productivity by increasing the number of work zones while indirectly placing motorists at risk.

What causes concrete deterioration?
In much of the United States, concrete deteriorates as a result of repeated freezing and thawing. Damage often is exacerbated by multiple applications of deicing salts, which accelerate cracking, deterioration, and surface scaling. Concrete life can be increased by improving its ability to endure repeated freeze-thaw cycles over its expected design life.

Putting It in Perspective

- Freeze-thaw issues are not confined to northern States.
- Even temperate States such as Texas and California have regions where freeze-thaw damage occurs.
- Freeze-thaw damage may not become apparent until 10 to 15 years after construction.
- The current quality control (QC) state-of-the-practice (pressure meters) cannot characterize air void spacing and only provides information on the total volume of air.

How do air voids affect the freeze-thaw resistance of concrete?
The presence of closely spaced air voids in concrete is commonly singled out as the primary factor in improving the freeze-thaw resistance of concrete. Researchers believe that as water expands during freezing, the pressure the water develops increases in relation to the distance it must travel to reach the nearest air void. Consequently, the more closely air voids in concrete are spaced, the less likely it is that the pressure of freezing water will damage the concrete.

Solution: Air void analyzers allow real-time testing of fresh concrete

The air void analyzer (AVA) offers an efficient, real-time method for assessing the distribution of air voids in fresh concrete. The device can characterize the distribution of air voids in less than 30 minutes. With this information, adjustments can be made in the concrete batching process to ensure that air voids are spaced properly.

How does AVA work?
A small mortar sample (20 milliliters (0.68 fluid ounces)) is extracted from the surface of fresh concrete using a vibrating cage and a syringe. The extracted mortar is injected into an assembly containing liquids with carefully controlled viscosities. As the mortar is injected, stirring releases trapped air bubbles, which rise through the liquids toward a buoyancy recorder at the top of the assembly. The rate that the bubbles rise is a function of their size. A data collection system tracks the change in buoyancy over time, and software determines the size distribution of the bubbles. The entrained air content, spacing factor, and specific surface are calculated from this data.

Benefits

- Provides timely results for onsite adjustments.
- Measures air void characteristics, not just volume.
- Allows for rapid in situ QC and quality assurance testing.
- Can be used as a risk minimization tool.

Successful Applications: AVA use prevents premature concrete deterioration

The Kansas Department of Transportation (DOT) began using AVA in 2001 because of premature joint deterioration in 10-year-old concrete pavements. Sealing a deteriorated joint cost $3.25 per meter ($1.00 per foot), and additional sealing was anticipated over the remaining life of the pavement. In 2002, the Kansas DOT developed a concrete specification based on AVA. It now uses AVA for concrete mix qualification, with job site acceptance based on total air content. Cost savings from reduced repairs are estimated at $1.1 million for 2001–2002 projects.

Since 1999, the Federal Highway Administration (FHWA) has used AVA technology on projects in nine States. The variety of projects include pavements, precast sheet pile, foundation elements, and bridge decks. Roughly half of the concrete samples tested (using both AVA and hardened air-content tests) had air void spacing factors outside the generally accepted limits for durable concrete, even though air content specifications (using conventional QC tests) were met. Results were based on 36 concrete samples collected on 9 projects. These results highlight the importance of implementing AVA to prevent appreciable quantities of concrete from being placed with inadequate freeze-thaw resistance.

Deployment Statement

The air void analyzer can be used to measure entrained air content, specific surface, and spacing factors of fresh portland cement concrete (PCC). The real-time evaluations done using AVA can improve quality control.

Deployment Goal

By 2008, a common standard test protocol and specifications will be developed. In addition, all State DOTs using significant amounts of PCC will use AVA on major concrete bridge and pavement projects.

Deployment Status

At least 16 States used AVA on a limited basis in 2005, including Arkansas, California, Delaware, Iowa, Kansas, Minnesota, Missouri, Nebraska, Nevada, New York, North Carolina, North Dakota, Oklahoma, Pennsylvania, Texas, and Utah.

Additional Resources

More information on the AVA, including case studies on States using the technology, is available at **http://aashtotig.org?siteid=57&pageid=697**. To learn more about AASHTO-TIG's approved technologies, visit **http://tig.transportation.org**.

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