U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Air Void Analyzer

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 is deteriorating 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 life cycle.

How do air voids affect the freeze-thaw resistance of concrete?
Closely spaced air voids in concrete are 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.

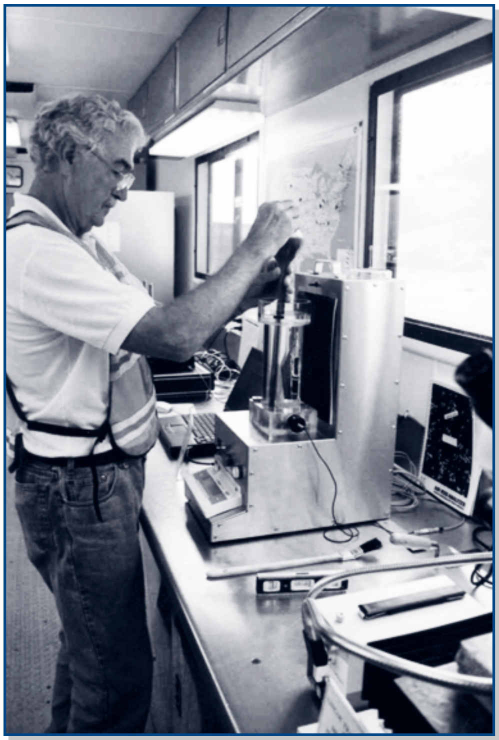
Putting It in Perspective

- Freeze-thaw issues are not confined to northern States.
- Even temperate States such as Texas and California have regions where pavement freezing occurs.
- Freeze-thaw damage may not become apparent until 10 or 15 years after construction.
- Current quality control (QC) state-of-practice (pressure meter) cannot characterize air void spacing.

Solution: Air void analyzer allows 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 air void distribution 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 the AVA work?
The AVA uses a small mortar sample (20 milliliters (0.68 fluid ounces)) 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 viscocities. As the mortar is injected, the air bubbles are released and rise through the liquids toward a boyancy recorder at the top of the assembly. The rate of rise of the bubbles 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. From this data, the total air content, spacing factor, and specific surface are calculated.



Extracting an AVA sample

Successful Applications: AVA use prevents premature concrete deterioration

The Kansas Department of Transportation (DOT) began using the AVA in 2001 because of premature joint deterioration in 10-year-old concrete pavements. Sealing a deteriorated joint costs $3.25 per meter ($1 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 the AVA. It now uses the 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 included pavements, precast sheet pile, foundation elements, and bridge decks. Roughly half of the concrete samples tested (using both the 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 these 9 projects. These results highlight the importance of implementing the AVA to prevent appreciable quantities of concrete from being placed with inadequate frost resistance.

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.

Additional Resources

More information on the AVA, including case studies on States using the technology, is available at www.aashtotig.org/focus_technologies/ava/.

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