TDOT Department of Transportation

Research Summary

Enhancing Freeze-thaw Resistance of Tennessee Concrete Mixes Through Improved Air Void Testing

Project Number:
RES2020-09

TDOT Lead Staff:
Jonathan Vest
Materials & Tests Division

Principal Investigator(s):
Baoshan Huang | PI
University of Tennessee - Knoxville

Project Term:
October 2019 to May 2022

WHAT WAS THE RESEARCH NEED?

Freeze-thaw damage is the widest deterioration type of concrete structures in cold climate regions. The air-void system in concrete plays a critical role in the resistance of concrete to freezing and thawing cycles by providing additional space to reduce internal pressure caused by frozen water. The most commonly used methods to evaluate the freeze-thaw durability and air-void system of concrete are only used for hardened concrete rather than fresh concrete, seriously lagging behind the construction schedule of concrete. The Super Air Meter (SAM) is a recently developed test device for fresh concrete, which is easily performed on the job site providing results in real-time. The main aim of this study was to investigate the applicability of the SAM to Tennessee Department of Transportation (TDOT) concrete mixes

WHAT WERE THE RESEARCH OBJECTIVES?

The objectives of this study were to:

1. Evaluate the applicability of the SAM meter and SAM number for TDOT concrete mixes.
2. Evaluate the consistency of the SAM number measurements for TDOT concrete mixes.
3. Determine the threshold of the SAM number for QA/QC purposes for TDOT concrete mixes.
4. Provide guidance/recommendations on the acceptable parameters for TDOT concrete mixes if the SAM test method is applicable in Tennessee.

Sponsored by Tennessee Department of Transportation Long Range Planning
Research Office & Federal Highway Administration

WHAT WAS THE RESEARCH APPROACH?

A synthesis of literature review on the latest advances in the SAM test method and a state Department of Transportation survey on their acceptance criteria of the SAM number for adequate freeze-thaw resistance of concrete were conducted. Then, various concrete mixes in TDOT specifications across Tennessee on the job sites and in the laboratory were tested for their SAM numbers, as well as other air void parameters, and the freeze-thaw durability factor from ASTM C666/AASHTO T161. After that, a comprehensive statistical analysis of the test results was performed to acquire the correlations between the SAM number, freeze-thaw durability factor, and other air-void parameters. From there, the threshold value of the SAM number was determined. Finally, based on the results and findings from this study, recommendations were made to TDOT specifications regarding the application of the SAM and acceptance criteria of the SAM number for TDOT concrete mixes.

WHAT WERE THE FINDINGS?

The main findings of the study include:

- For TDOT concrete mixes in different regions, the measured SAM number varies widely, indicating there is no good consistency of the SAM number in various locations. The variation of the SAM number actually reflected the difference in the air void system of fresh concrete mixes.
- For TDOT concrete mixes, the SAM number shows a decreasing trend with the increase of air content of fresh concrete.
- For TDOT concrete mixes, there is a good correlation between the SAM number and freeze-thaw durability factor: a SAM number of 0.2 shows a correlation to a durability factor of 80% with 81% agreement; a SAM number of 0.3 shows a correlation to a durability factor of 80% with 85% agreement.
- For TDOT concrete mixes, there is a good correlation between the SAM number and spacing factor: a SAM number of 0.2 shows a correlation to a spacing factor of 0.2 mm with 83% agreement; a SAM number of 0.3 shows a correlation to a spacing factor of 0.3 mm with 89% agreement.

IMPLEMENTATION AT TDOT

The SAM is applicable to TDOT concrete mixes to evaluate the air void system and freeze-thaw resistance, and the SAM number can be adopted as a QC/QA tool. Not only should the air content for fresh concrete meet TDOT specification (e.g., 4%~8% for Class A, 4.5%~7.5% for Class D), but also an appropriate SAM number is recommended: from a conservative perspective, a SAM number below 0.2 can be considered as good enough to ensure concrete has sufficient freeze-thaw durability factor (e.g., higher than 80%); a SAM number between 0.2 and 0.3 can be considered as acceptable to ensure concrete has a freeze-thaw durability factor meeting the failure limit (e.g., higher than 60%); and a SAM number above 0.3 can be considered as rejectable.

MORE INFORMATION

Find the final report here: https://www.tn.gov/content/dam/tn/tdot/long-range-planning/research/final-reports/res2020-final-reports/RES2020-09_Final_Report_Approved.pdf.

Sponsored by Tennessee Department of Transportation Long Range Planning
Research Office & Federal Highway Administration