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The Super Air Meter (SAM) is a testing device that measures both the air void spacing and air volume of plastic (fresh) concrete in about 10 minutes. Air void spacing has been shown to be a better indicator of concrete freeze-thaw durability than total air content; however, until now, it has been challenging to measure in fresh concrete. By being able to measure the actual air-void spacing in fresh concrete, the meter helps users better understand the freeze-thaw durability of their concrete before it is placed.

The meter can function in two ways. First, it provides all the same information as a Type B meter, under the same analytical conditions as a conventional pressure meter. After completing the conventional testing the meter is then able to move into a second mode of operation that places the concrete under a series of higher pressures. By understanding how the concrete responds to the series of high pressures the meter can assess properties of the air-void system beyond the air content.

The Super Air Meter is a modified version of a typi-cal pressure meter (ASTM 231). The primary modification is that two sequential pressurizations are applied to the concrete. The deformation of the concrete is first investi-gated at 14.5, 30, and 45 psi, the pressure is then released, and the same pressure steps are used again to measure the deformation. The differences between the first and second pressure steps are used to calculate the SAM number, which is correlated with the average spacing between air voids in the concrete mixture. If the spacing between the voids is too high, then this could mean the concrete is susceptible to freeze-thaw deterioration. A SAM number of 0.20 has been shown to correctly determine over 90% of the time whether the spacing between the bubbles meets the recommenda-tions of the ACI 201 Concrete Durability Committee.

This new air meter has been investigated using more than 300 lab and field mixtures at Oklahoma State University and the FHWA Turner Fairbanks Laboratories. As part of an ongoing Pooled Fund Study, the SAM is being used by 10 different DOTs on field concrete. The results of this testing are also being compared to performance in an ASTM C666 rapid freeze-thaw test*. An AASHTO Provisional Standard for this test has been approved. The meter is currently being used in 22 different U.S. States and one Canadian Province. The SAM has been specified in Oklahoma and Michigan on transportation projects.

Producing Freeze-Thaw, Durable Concrete

When concrete is in a wet environment and exposed to freeze-thaw (F-T) cycles, tensile stresses develop within the concrete. Localized damage to the surface of concrete can also occur when deicing salts are used. Concrete is most at risk for this type of damage when it is close to being saturated. This can lead to damage in just a few F-T cycles.

Why do we entrain air in concrete?

To protect concrete from F-T damage, a soap or surfactant, called an air entraining admixture (AEA), is added while the concrete is mixing. An AEA helps stabilize air-voids that are spherical and typically between 0.0005″ and 0.05″ in diameter. After the concrete hardens, these voids help reduce damage from freezing. In addition, entrained air also improves the workability of fresh concrete, and can reduce segregation and bleeding. Entrained air will reduce the strength of the concrete mixture. Typically for every 1% increase in air content this causes a reduction in the compressive strength of about 500 psi. While entrained air is important to the F-T durability of concrete, it is also critical to use F-T durable aggregates, and a cement paste that is strong and moisture resistant.

For example, concrete mixtures with modern AEAs have been shown to only need 3.5% air in the concrete to provide satisfactory air-void systems and sufficient performance in rapid F-T testing in paving mixtures. However, when combinations of AEAs and water reducers (WRs) were investigated, this was found to produce bubble systems that were larger and of lower quality at a given volume of air. This means that higher air contents were needed. This research found that mixtures with air content as high as 7% were found not to perform well in the F-T testing when certain WR and AEA combinations were used. This research highlights how specifications that use total air volume to specify air content can be inadequate and that air-void quality is more representative of F-T performance.

How do we know we have a good air-void system?
The most widely used method to measure the quality of the air-void system is ASTM C457 "Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete"*. In this test hardened concrete is cut, polished, and then inspected with a microscope with a standardized method to measure the void sizes and spacing. This test reports the total volume of air as well as a parameter called the spacing factor. The spacing factor is recognized as the primary measurement of air-void system quality. Rapid laboratory F-T testing found that a spacing factor of approximately 0.008 in was needed to provide F-T durability.

One challenge with the ASTM C457 test is that it takes weeks to obtain the results. The test is also expensive and requires specialized equipment and personnel. As discussed previously, most specifications rely on the measurement of the total volume of air with either AASHTO T 152 (ASTM C231) "Test for Air Content of Freshly Mixed Concrete by the Pressure Method", AASHTO 196 (ASTM C173) "Standard Method of Test for Air Content of Freshly Mixed Concrete by the Volumetric Method", or AASHTO 121 (ASTM C138)"Standard Method of Test for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete". Because these tests only measure the air-void volume, their results are not always a good indicator of air-void quality. Recent research at Oklahoma State University has led to the development of the Super Air Meter, which is able to measure the quality of the air-void system in fresh concrete. The device and sample preparation have many similarities to the AASHTO T 152 (ASTM C231) pressure meter, but the SAM test method uses higher pressures and a larger number of pressure events to determine the volume, and quality of the air-void system in fresh concrete. The test takes less than 10 minutes to run and the meter provides both the air content as determined by AASHTO T 152 (ASTM C231) and a new measurement called the SAM number that correlates with the void spacing or the spacing factor. A SAM number of 0.20 has been shown, over 90% of the time, to correctly determine whether the spacing factor is above or below the 0.008 in limit based on the laboratory and field testing.

Includes one Super Air Meter testing device, and all accessories required to calibrate the meter and perform the type B or SAM tests. This includes a calibrator; a mallet; safety glasses; strike-off board; a tamping rod; filling bulb and a durable, protective case.