OPEN FORUM
PROBLEMS AND SOLUTIONS

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Air Entrainment for High Performance Concrete

Q1: Does high performance concrete (HPC) need to be air entrained for frost resistance?

A1: The primary purpose of air entrainment in concrete is to improve concrete's resistance to cycles of freezing and thawing when exposed to water or deicing chemicals. Consequently, concrete in an environment that does not experience freeze-thaw cycles, and hence the use of deicing chemicals, does not need to be frost resistant. Air entrainment, therefore, is not necessary for concrete in these locations. This is true for both HPC and conventional concretes.

Structures in locations that experience freeze-thaw cycles are also likely to be exposed to ice and snow storms and the use of deicing chemicals. In these locations, HPC members that have the potential for being critically saturated when exposed to freeze-thaw cycles must be frost resistant.

A recent PCA publication contains the results of tests on high-strength concrete for frost and scaling resistance.[1] All tests were made on concretes with portland cement as the only cementitious material. Tests for resistance of concrete to rapid freezing and thawing were made in accordance with ASTM C 666 Method A after 14 days of drying. Durability factors close to 100 were only achieved without air entrainment when the water-cement ratio was equal to or less than 0.35. Tests for scaling resistance of concrete surfaces exposed to deicing chemicals were made in accordance with ASTM C 672. Resistance to scaling of non-air-entrained concrete was only achieved when the water-cement ratio was reduced to 0.25.

Most bridge decks in locations that experience freezing and thawing are directly exposed to freezing rain, snow, and deicing chemicals. It is also likely that the concretes used in these bridge decks have water-cementitious materials ratios of about 0.40. No well-documented field experiments have been made to prove that air entrainment is not needed in HPC. Until such data are available, current practice for air entrainment should be followed for decks and other bridge elements exposed directly to deicing chemicals.

In contrast to decks, HPC bridge beams are generally made with high-strength concrete. This requires the use of a water-cementitious materials ratio of less than 0.40, which offers the potential for frost resistant concrete with a lower percentage of air entrainment or even no air entrainment. At the same time, bridge beams are protected by the bridge deck from direct exposure to moisture and deicing salts. High-strength concretes also have a lower permeability than conventional strength concretes and moisture penetration is likely to be less. Non-air-entrained girders used on the Illinois Toll Road bridges built in 1957-58 are still performing well. Since the use of air entrainment in high-strength concrete reduces the compressive strength by about 5 percent or about 500 psi (3.5 MPa) for each 1 percent increase in air content, it is desirable to minimize the air content in order to achieve the strength.

All of this indicates that the need for air entrainment is less critical in HPC bridge beams than in decks. As with all HPC applications, the specified properties must be consistent with the intended application and environment. The need for air entrainment in HPC bridge beams should be based on local conditions and practices.

REFERENCE

1. Pinto, R. C. A., and Hover, K. C., "Frost and Scaling Resistance of High-Strength Concrete," PCA Research and Development Bulletin RD122, Portland Cement Association, Skokie, IL, 2001, 74 pp.

[Based on an article in HPC Bridge Views (Henry G. Russell, Editor), published jointly by the FHWA and National Concrete Bridge Council.]