AIR ENTRAINMENT REQUIREMENTS

Freeze thaw durability is an important physical property of cast stone and ASTM C1364 Standard Specification for Architectural Cast Stone has specific performance requirements. ASTM C1364 requires that both "wet cast" and "dry cast" produced cast stone have a maximum 5.0% weight loss when subjected to 300 rapid freeze-thaw cycles, as per ASTM C666. But to produce durable cast stone, it is important to understand the mechanisms that cause concrete to deteriorate in freeze/thaw environments.

Freeze/thaw damage occurs when the pore structure of the cast stone becomes fully saturated with water and cycles between freezing and thawing. Because water expands about 9% of its volume when it freezes, the concrete cannot withstand these expansive forces and the cast stone can fail overtime. And the problem is exacerbated when the cast stone is exposed to deicing salts.

In the late 1930's air-entraining admixtures (ASTM C260) were developed for slump concrete to increase their resistance to freeze/thaw degradation. Air-entraining admixtures form microscopic bubbles in the cement paste of the concrete matrix. According ACI 212.2R Admixtures in Concrete, there have to be enough bubbles, of the correct size and properly spaced (spacing factor) in the cement paste to be effective. Below are images from polished cross sections made from wet cast concrete illustrating different entrained air content.

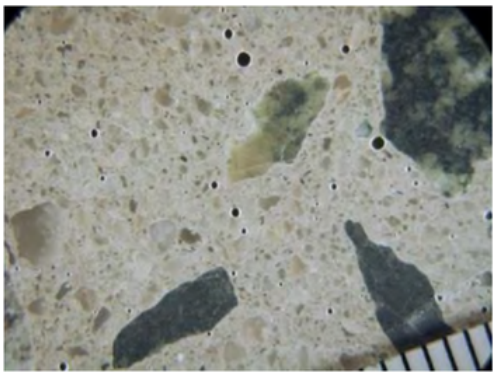

Figure 1 1.0% Hardened Air

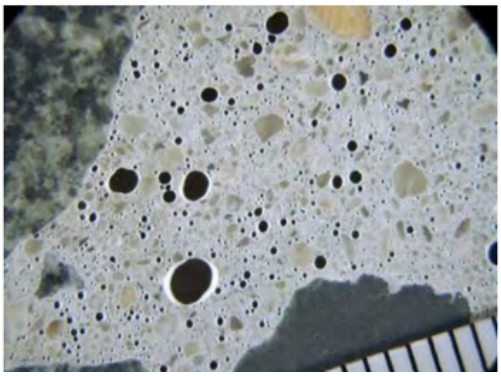

Figure 2 6.0% Hardened Air

During the freezing phase, these microscopic bubbles provide a hydrophobic void for the freezing water front to migrate into so that the freezing water will not expand in the capillary pores to a point where it will damage the paste structure. Upon thawing, the bubbles release the water and become empty and ready for the next freeze cycle. While not required, it is recommended that cast stone made with slump concrete contain an air entraining admixture to minimize freeze-thaw damage. Air entraining admixtures are an effective, low cost option to improving freeze/thaw durability of wet cast produced cast stone.

Experience has shown that traditional air entraining admixtures are not as effective for cast stone manufactured with zero slump concrete. Vibrant Dry Tamped cast stone (VDT) is manufactured using earth moist mixes having just enough water to make a compactable concrete mixture. This lack of water makes it difficult to produce properly spaced and stable air bubbles. Petrographic analyses of cast stone made with air-entraining admixtures have shown that the microscopic spheres, if any are detected, are not uniformly spaced throughout the mix, thus rendering the admixture less effective.

Vibrant dry tamp cast stone typically perform well in laboratory testing and in-situ. This is because the mixes are a cement rich mix, contain low water content and reduced capillary pores structure. Therefore, VDT cast stone has an appropriate pore structure, which will accommodate the hydraulic pressure necessary to prevent distress during freezing and thawing cycles.

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There are a number of factors that affect how cast stone performs in freeze/thaw environments, but from a manufacturing standpoint, well performing cast stone starts with quality aggregates, cementitious materials and admixtures. Not only is it important to use quality materials, but they have to be properly proportioned, batched, placed or formed and cured. It's only through laboratory testing that the manufacturer can demonstrate that their cast stone complies with specifications.