Technical Bulletin 9

Fly Ash Increases Resistance to Freezing & Thawing

FREEZE/THAW DETERIORATION BEGINS when water enters voids in concrete. Leaching of calcium hydroxide, producing the hydration of portland cement, provides greater voids for water to occupy, thereby aggravating the rate of deterioration. Upon freezing, this water expands in volume 9%, generating pressures of 30,000 psi.

This tremendous pressure greatly exceeds the capacity of concrete to resist it, and the concrete is forced apart from within. Deterioration provides ever easier paths for water to penetrate into the concrete, resulting in greater disintegration as freeze/thaw cycles continue.

Concrete deterioration from freeze/thaw cycles has been and continues to be a major problem in cooler areas of the country. Use of fly ash concrete mixes can help reduce exposure to damage.

Entrained air voids have been found to be particularly useful in resisting the destructive action of freeze/thaw cycles. Theory has it that each of the microscopic air voids purposefully put into the concrete acts as a pressure release vessel. The pressure exerted as water turns to ice finds a point of release in these numerous small air voids.

ACI Recommendations

Even though entrained air is put into concrete, certain conditions must accompany it in order for the concrete to successfully resist deterioration. The American Concrete Institute (ACI) recommends that the concrete producer take steps to:

1. Introduce the proper percentage of suitably sized and spaced air bubbles into the concrete.
2. Provide a minimum level of compressive strength (typically 4,000 psi).
3. Proportion the mix for low concrete absorption.
4. Design the concrete for high density and low permeability.
5. Assure that the concrete be properly cured, then dehydrated, prior to exposure to freeze/thaw.

Fly Ash – A Valuable Aid

High quality fly ash can be a concrete producer's most valuable asset in achieving all five objectives stated. High quality fly ash works as follows:

1. Fly ash combines with calcium hydroxide to produce additional cementitious materials, thereby reducing the amount of calcium hydroxide that may be leached out of the concrete. Leaching of the calcium hydroxide increases concrete voids which can accelerate freeze/thaw damage. As a result, permeability and porosity are reduced.
2. Fly ash fills the minute voids that no other part of the mix can fill, thus creating a more dense and less absorptive concrete.
3. Fly ash reduces the amount of water required in the mix by approximately 2% to 10%, because the spherical shape of the fly ash particles reduces bleed channels and void spaces. Reducing bleed channels limits the entrance of water; fewer void spaces mean less space for water to accumulate.
4. Fly ash helps maintain an even distribution of entrained air through the plasticizing effect that fly ash particles have on the concrete mix. High quality fly ash also produces more cohesive concrete which holds entrained air inside the concrete.
5. Fly ash helps produce higher compressive strengths long term that provide a strong concrete which resists the forces generated during the freezing of water in the voids.

Fly ash concrete is more stable, uniform, dense, less absorptive and less permeable—all factors which improve freeze/thaw durability.

For more information or answers to questions about the use of fly ash in specific applications, contact your nearest Headwaters Resources Technical Sales Representative or call 1-888-236-6236.

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