Raging Thunderlizard Evangelist for Change

Fly Ash—Cast in Concrete

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Introduction

Many texts have been written and more will follow on the topic of construction procurement. Any attempt to address this issue in a small space has limitations, so this article will not attempt to speak to the broader issue but will focus on one: alternative material selection. Our profession has the opportunity to materially affect the result and consequences of the construction process. Numerous opportunities exist to contribute throughout the entire process, but material selection is critical, and a great deal of help is available. Three such sources are Green Seal, The Environmental Protection Agency (EPA), and Environmental Building News. A review of these sources demonstrates the wide range of choices available to your specifiers. There are, however, products with less sizzle, but which have a much beefier impact. One is concrete. Concrete is important because it is costly and commands a huge environmental footprint. Higher education buys gigantic volumes every day. It is the second most consumed product on the planet.

What is Concrete?

Concrete is approximately 12% cement. For every ton of cement produced, a little over a ton of CO_2 is released into the atmosphere, representing from 7% to 12% of worldwide industrial CO_2 emissions. In 1997, global CO_2 emissions reached 21.6 billion tons, with 1.4 billion tons attributable to cement production alone. Every yard of concrete poured releases 630 pounds of CO_2 into the atmosphere. With cement production probably doubling in the next 25 years, we must make it our goal to reduce the accompanying CO_2 emissions.

The manufacturing and chemical processes of cement production release CO_2 during two steps. Cement production begins with grinding and then heating— in a rotary kiln, to 2700°F— a calcium source (typically limestone) and a silicon source (typically sand or clay). The high heat results in chemical and physical changes that enable cementitious bonding to occur. Production of one ton of cement uses six million BTUs of energy. Since coal is a cheap energy source, it is most commonly used in fueling the kilns, and this releases the largest amount of CO_2, approximately three-quarters of a ton of it per ton of cement.

The second source of CO_2 is a chemical reaction— the calcining of limestone into lime. This releases approximately one-half of a ton of CO_2 per ton of cement. A further reaction occurs at very high temperatures and results in the bonding of calcium oxide to the silicates. These then cool into "clinker" pellets that are ground into fine cement powder. Concrete is made by combining this fine powder, fine aggregate or sand, coarse aggregate, and water. Additives may be included in the mix to control specific performance issues, such as workability or set time. The concrete hardens with the addition of water, through a chemical reaction called hydration, which generates heat.

Enter the procurement professional who asks, "Is there an alternative material to cement?" And the answer is, of course, "Yes!" There are at least four alternatives, each with a greatly reduced CO_2 contribution. They are fly ash, blast furnace slag, silica fume, and rice hull ash.

What is Fly Ash?

Fly ash is one of several combustion byproducts of coal-fueled power plants. It is fine residue captured by pollution control equipment within the stacks, and treated as a waste product. It comprises the impurities in coal that cannot be burned. Those impurities fuse at high temperatures and become glass. Fly ash is 60% to 90% tiny glass beads. It reacts like cement when used in concrete.

The U.S. produces between 50 and 60 million tons of fly ash every year, approximately 75% of which ends up in landfills. The two classes of fly ash, Class F and Class C, are distinguished by the silica oxide content of the type of coal burned. Both Class F and Class C fly ash are effective replacements for cement in concrete. In other words, coal-fired power plants are cement factories that have pretty much been ignored to date.

Advantages and Challenges of Fly Ash in Concrete

The use of fly ash as a replacement for cement in concrete offers many advantages and little cost. The small size of the fly ash particles is key to producing smooth cement paste, allowing better bonding between aggregate and cement, and resulting in a more durable, impervious concrete. The round shape of the particles increases concrete's workability without adding extra water, a true cost-avoidance. Because fly ash concrete cures slowly, the heat of hydration is lower, resulting in less shrinkage and fewer thermal cracks. Most importantly, high-volume fly ash concrete actually gains strength over time, making it a durable concrete solution over the long term.

Challenges of Fly Ash Concrete

Some construction codes may restrict the fly ash content of concrete to 15% to 20%. Others may impose excessive water requirements and high early-strength requirements on the mix designs, and these are difficult to meet with high-volume fly ash. These codes do not focus on the ultimate strength and durability of the concrete. Some jurisdictions, fearful of the product, state in their specifications, "Fly ash concrete is to be used only with the written permission of the Structural Engineer." Other concerns include shortened finishing times, increased set times, increased costs because of delays in removing formwork, and the need for multiple test batches and finishing mock-ups. In short, a major challenge is to allay the fears of engineers and subcontractors over a material largely unfamiliar to them.

History

Folks, this is not a new product. We've simply forgotten about it. Both the Romans and the Greeks used fly ash to make concrete 2000 years ago. Volcanoes made it for them, not kilns. Many of the early structures survive today. The durability of the product is not an issue.

Opportunity

If creating a healthy, economical building is something you desire, you, too, can use fly ash. Moreover, your building can serve as an educational model for future structures. High-volume fly ash concrete contributes to the fiscal responsibility of your building by creating a stronger, more durable material, meeting or surpassing the demands of most 100-year life expectancies. A pedagogical opportunity can be created for other high-volume fly ash projects. Why not make use of a waste product in your backyard? Not only will it help create a local community of knowledgeable contractors and engineers, but it will also slow the speed of landfill unavailability in your area.

Coal-fired power plants exist near many of us. The cost of shipping fly ash need not be significant.

Before specifications, standards, and policies are set in concrete (pardon the pun), it should be imperative that the full extent of their impacts—environmental, social, fiscal—are well understood.

Conclusion

Concrete and its consequences are receiving worldwide attention. The World Business Council for Sustainable Development, a coalition of more than 150 international companies, has launched a Sustainable Cement project. The purpose is to improve the cement industry's ability to thrive in a changing marketplace—one that clearly understands the environmental and financial forces that drive it. Meanwhile, here in the United States, the Civil Engineering Research Foundation is preparing a major performance initiative aimed at fly ash and its role in concrete. Our rediscovery of a lost approach is well on its way to mainstream acceptance.

As a purchasing professional, you can contribute to the solution by inserting fly ash into the construction equation. You have many roles to play in the process, and material selection is one that you probably have not played before. This single material can open the door to opportunities and long-term benefits for your institution and all human beings coming in contact with it. Be brave. Step into this issue.

Do great things!

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