Home
Features:
Tenders
UAE Focus
Germany & the Mideast
Barr Al Jissah Resort
Qatar
Oman
Fire Protection
Doors & Gates
Excavators
Hospital Construction
GRC
Ground Engineering
Rebar

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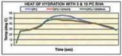
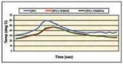
Technical Focus

Rice husk ash enhances concrete

Reader Enquiry No. 21

Nazia Pathan studies the use of rice husk ash (RHA) in producing high-performance concrete and outlines the cost benefits that it offers.





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Rice husk ash (RHA) obtained from parboiling plants could be used to dramatically enhance the workability, strength and impermeability of concrete mixes, thereby producing concretes that are highly durable to chemical attacks, abrasion and reinforcement corrosion, a seminar on innovative technologies was told.

RHA and microsilica (MS) from ferrosilicon, are essentially super-pozzolans since they rich in silica and have about 85 per cent to 90

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per cent silica content and hence one of the best ways of using such materials is to use them for making 'high performance concrete' (HPC).
Research that has been carried out in this context has proved beyond doubt that by utilising super-pozzolanic materials even in small amounts (5 per cent to 10 per cent cement replacements) the properties of concrete can be significantly enhanced.

High performance concrete

Mixtures with high workability and very high early strengths are called high performance concrete by some researchers. Others consider high workability and long-term durability as primary characteristics for high performance. High early strength is not necessary, but high ultimate strength is.
The incorporation of fine particles of MS or RHA dramatically enhances the workability and impermeability thus making the concrete durable.
However, the contribution of MS or RHA to strength is relatively small in low water-cementitious ratio in HPC mixtures. The high strength of these HPC mixtures are attributable to extremely low water-cement ratios resulting from the application of a large dose of superplasticizer, which is added to the concrete mix for properly dispersing the fine particles of the pozzolanic admixture. The pozzolanic reaction associated with silica fume will make a contribution to strength, however, this contribution is relatively small with small amounts of MS or RHA used (typically five per cent to eight per cent of cement mass).
There is a general agreement that with a cement replacement ratio of 10 per cent MS or RHA, results in increasing the compressive strength in the range of 10 per cent to 20 per cent.
With the given water content, the workability of a concrete mixture can be improved by controlling segregation and bleeding through the use of high cement content or a more finely ground high early-strength Portland cement. But this is seldom a satisfactory solution to the long-term durability problems in severe environments because concrete mixtures containing high cement content or high-early-

strength Portland cement are prone to cracking from thermal-drying and chemical shrinkage. As a result of exposure to cycles of wetting-drying, heating-cooling, and loading-unloading, concrete in service becomes permeable when cracks and micro cracks interlink the large pores or voids in the microstructure.

From the standpoint of durability, a better way to improve the workability of a concrete mixture is through the incorporation of fine-particle materials, which are less reactive than Portland cement. If well distributed in the cement paste, the particles of MS or RHA segment the bleed-water channels and consequently prevent bleeding and segregation and thereby improve workability.

The physical effect, followed by the chemical effect involving the pozzolanic reaction (in which the calcium hydroxide formed during hydration of cement in concrete reacts with the silica present in the admixture to form calcium hydride silicate), fills up the empty spaces and results in the densification (pore refinement) and strengthening of the microstructure.

This is particularly high in the porous and crack-prone interfacial zones that exist in the vicinity of coarse aggregate particles. Studies have shown that 10 per cent cement replacement with MS or RHA can reduce large pores of the order of 100 nm size in hydrated cement pastes to much smaller pores in 1 to 10 nm range.

It has also been observed that such transformation of an open-pore system into a closed-pore system through the process of pore refinement has a much greater effect on the permeability than on the strength of the materials.

Manufacture of RHA

Rice husks produced during the de-husking operation of paddy rice, present an enormous disposal problem for rice milling areas. When burnt under controlled conditions, RHA is highly pozzolanic and is suitable for use in lime-pozzolana mixes and for Portland cement replacement.

Each tonne of paddy produces about 200 kg of husk, which on combustion yields approximately 40 kg of highly siliceous ash in addition to 3,800 kca/kg of heat energy. In the conversion of rice husks to ash, the combustion process removes the organic matter and leaves the silica-rich residue. However, such thermal treatment of the silica in the husk results in structural transformations that influence both the pozzolanic activity of the ash and its grindability.

Prolonged heating of rice husk at temperatures beyond 800 deg C produces essentially crystalline silica. Uncontrolled combustion of husks as fuel for making clay bricks or for steam generation in parboiling rice plants produces ash, which is not completely amorphous. Due to the crystalline components in the ash, it is referred to as hard burnt ash.

The reactivity of the ash is related to its surface area and the amount of amorphous silica. However, the reactivity has to be balanced against water demand, as the high specific surface of RHA will significantly increase the amount of water required to produce a workable concrete.

In order to obtain ash of acceptable reactivity with lime, it has to be ground for periods as long as seven hours if the ash crystalline ash or as little as 15 minutes if the ash is amorphous. The ash is usually ground to appropriate size in a conventional ball mill, using a charge of steel balls. The compressive strength increases as fineness increases.

Most investigations have sought to utilise the reactive nature of amorphous silica in ash obtained from controlled pyroprocessing. Little has been reported about the characteristics of RHA, obtained during uncontrolled combustion, as an admixture for concrete.

* This paper was presented at the National Seminar on Innovative Technologies in the Construction of Concrete Structures in India.

Reader Enquiry No. 21

Back to Top

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