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Cement & Concrete Composites

Editorial

Sustainable development in the cement and concrete industry has now become a matter of great and urgent concern to all those involved in the production and use of concrete in construction. To appreciate the global impact of the concrete industry on our environment and that of the environment on the construction industry, we need to understand what has happened to the world we live in during our lifetime. There have been, particularly during the last four to five decades, unprecedented social changes, unpredictable upheavals in world economics, uncompromising societal attitudes, and unacceptable pollution and damage to our natural environment. In global terms, these social and societal transformations can be categorized in terms of population growth, technological revolutions, worldwide urbanization and uncontrolled creation of atmospheric pollution and waste.

The impact of this global urbanization, and the disproportionate consumption of energy and world resources between the industrialized nations and the developing world, have not only resulted in a dramatic increase in the demand for energy sources, but also in turn have placed insatiable demands on the construction industry in terms of the world's material and energy resources. In this complex world scenario, infrastructure regeneration and rehabilitation, and cement and concrete materials have an undeniable part to play in enhancing the quality of life.

Whatever be its limitations, concrete as a construction material is still rightly perceived and identified as the provider of a nation's infrastructure, and indirectly, to its economic progress and stability, and indeed, of the quality of life, because it is so easily and readily prepared and fabricated into all sorts of conceivable shapes and structural systems in the realms of habitation, transportation, water supply, sanitation, work and play. However, in spite of the excellent known performance of concrete in normal and moderately aggressive environments, and in spite of its being more ecologically friendly than metals and plastics, portland cement remains both as a resource- and energy-intensive material. Every tonne of cement requires about 1.5 tonnes of raw material, and about 4000 to 7500 MJ of energy for production. Much more importantly, every tonne of cement also releases 1.0 to 1.2 tonnes of carbon dioxide into the atmosphere by the time the material is put into place. About one half of the CO_2 emissions arises from the calcination of the major raw material used in the production of cement, namely limestone. The rest is primarily due to the combustion of fossil fuels, and depends on the carbon content and efficiency of the fuel usage. In addition, minor amounts of NO_x and CH_4 are also released into the atmosphere during cement production.

Currently, the annual amount of cement production, globally, is of the order of 1.4 billion tonnes, resulting in the making of some 7 billion tonnes of concrete. On average, therefore, the cement industry is responsible for the creation of about 1.4 billion tonnes of CO_2 annually in the atmosphere. Recent world events and the World Earth Summits in Rio de Janeiro in 1992 and in Kyoto in 1997 remind us sharply that the uncontrolled increase in the emssion of greenhouse gases to the atmosphere is not only environmentally unacceptable but will also impede sustained development. The manufacture of portland cement is a direct contribution to CO_2 emissions, and the most immediate, positive and direct approach to reduce these emissions is through the use of large volumes of fly ash and other supplementary cementing materials such as ground granulated blast-furnace slag in the composition of concrete.

High volume fly ash (HVFA) concrete offers a new technology of high performance, excellent durability and an environmentally friendly construction material. Having a much higher fly ash content, of 50 to 60 per cent by mass of the total cementitious material, HVFA concrete has a particular special attraction because of its suitability for a wide range of infrastructure constructions. The technology of high volume fly ash and slag concrete has been pioneered both by the University of Sheffield, and the Canada Centre for Mineral and Energy Technology. In the HVFA concrete developed at Sheffield, cube compressive strengths of 12 to 20 MPa can be achieved in 3 days, and 20 to 32 MPa at 7 days, and 30 to 40 MPa at 28 days, leading to 55 to 63 MPa at one year. The mixture of this particular HVFA concrete will contain a small

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amount of a highly reactive pozzolan such as silica fume to accelerate early hydration reactivity, and to enhance the pore refinement of the resulting concrete matrix. The water to cementitious materials ratio of the mix is kept low at 0.40, to ensure continued pozzolanic activity of the large volumes of fly ash contained in the concrete, and to enable continued hydration and densification of the cement matrix, particularly when exposed to hot/dry environments from an early age. The mixture may also contain additional fly ash as part replacement of sand. Tests show that such concretes can have excellent resistance to freezing and thawing, chloride–ion penetration, sulphate attack and water permeability.

We live in a world where engineers cannot afford to ignore the impact of the construction industry on our surroundings. The concrete industry has a direct and visible influence on world resources, energy consumption, and on carbon dioxide emissions. The wider use of cement replacement materials will contribute to reduce environmental pollution through reduced carbon dioxide emissions; it will further reduce energy consumption, consumption of raw materials and make a cleaner environment possible. Above all, cement replacement materials should be seen as vital and essential constituents of concrete, which alone in the long run can lead to sustainable growth of the cement and concrete industry.