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Editorial

One often wonders why engineers still hold considerably reservations on the ability of lightweight aggregate concretes to provide long and durable service life in many different environments. If one looks at research effort as a pointer for information and knowledge, there are extensive research data on the engineering and durability properties of a wide range of structural lightweight aggregate concretes readily available in literature. If, on the other hand, one looks at the practical side, there are many notable and successful applications of the material from bridges and off-shore structures to all forms of infrastructure. So the question lingers — why don't we utilise lightweight aggregates to a greater extent than what we do now?

That structural lightweight aggregate concretes can offer many economic and technical benefits for a wide range of practical applications through their ability for enhanced strength and durability without increased density is indisputable. Aggregates form one of the basic components of concrete, and for many parts of the world, concrete, compared to most other construction materials, possesses the best ecological profile for a given engineering property such as strength or elastic modulus. Concrete also represents the most ideal material for infrastructure construction and rehabilitation, that is so essential for a nation's stability and economic progress, and indeed, the quality of human life. It is estimated that world-wide annual production of cement by the year 2000 will be some 1800 million tonnes, which will require some 15 000 million tonnes of aggregates. With the rapid and dwindling resources of natural aggregates, the use of synthetic lightweight and recycled aggregates can have major environmental impacts in terms of waste minimisation, conservation of energy and resources, and reduction in pollution. Lightweight aggregates occupy a special place in this respect as they are often produced from industrial by-products which pose severe and expensive disposal and pollution problems.

Fly has has a very special role in this scenario for it provides not only the basic ingredient for the production of lightweight aggregates by the sintering process, but also offers a good pozzolanic and/or cementitious cement replacement material. Fly ash aggregates produced by the sintering process consist mainly of silica (about 30–60%) and alumina (15–30%) with smaller amounts of calcium, iron, magnesium and potassium. They are also chemically inert to most substances encountered in building construction, and in particular, immune to alkali–aggregate reactions.

That the presence of fly ash can also enhance the engineering properties of concrete both in the fresh and hardened states, and particularly its durability aspects, has also been proven beyond a shadow of doubt. Incorporation of fly ash in the cement paste system can thus directly lead to a very favourable pore refinement of the matrix, and this, in turn, can significantly reduce chlorides diffusing through fly ash concrete.

It therefore stands to reason that a combination of fly ash aggregates and Portland cement–fly ash matrix should be able to produce a uniquely high quality concrete system capable of meeting the demands of the construction industry. Indeed, tests show that there is a close chemical affinity between, and within, the constituents of this type of concrete, and that this can create an excellent aggregate–matrix bond which is a key factor contributing to the durability of concrete materials.

Extensive test data on the mix design, strength and elasticity properties of concrete made from fly ash aggregates and lightweight fines or sand, and having 28 day cube strength of 30–80 MPa are now available. Tests on reinforced concrete beams made with such aggregates show that structural members can readily satisfy the serviceability requirements of deflection and cracking, and that thay possess adequate ductility and factors of safety at failure. Such concretes can also develop strains of 2500–5000 microstrains prior to failure in bending. Shear failures in lightweight aggregate concrete members, on the other hand, can be a bit more complex, because of the differences in the magnitude of the diagonal tension resistance, which arises from differences in bond stress, strength under combined stresses, and more specifically, from the shear contribution through aggregate interlock. One cannot therefore expect unique relationships to predict the shear strength of beams made with a wide range of lightweight aggregates, and such beams can be satisfactorily designed against shear failure.

Fibre reinforcement is particularly attractive and beneficial to lightweight aggregate concrete structural members, especially where shear stresses are involved. Fibres perform two significant roles in such concretes. They effectively bridge cracks, preventing their excessive opening and contributing significantly to the post-maximum load deformation and strain softening. As a result of this crack control, the shear cracking load and the failure load can be enhanced, particularly in slabs failing in punching shear, leading to enhanced ductility and energy absorption properties.

Recent tests show that combinations of fly ash or slag together with a highly reactive pozzolan such as silica fume can still further enhance the engineering and durability properties than when these materials are used alone. For example, using fly ash lightweight aggregates and a total cementitious content of 350 kg/m^3 incorporating fly ash and/or slag together with a small amount of silica fume, cube compressive strength of 50 MPa at 28 days and 60 MPa at 180 days with an elastic modulus of 25 to 30 GPa can be obtained. Such combinations of supplementary cementing materials also result in extensive pore refinement far superior to what can be achieved with these materials alone. All these data simply confirm what we have known all the time — a correctly and well-proportioned lightweight concrete can provide high quality strength and durability properties for durable service life.