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Editorial

One is frequently asked the question as to why fibre reinforced cement and concrete (FRC) have not found as wide an application in the construction industry as one had hoped, and the industry had been led to believe. The very early research of Romualdi and Batson in the States, and that of Majumdar and his co-workers in the UK no doubt gave the impetus and motivation to understand the mechanics and principles of fibre reinforcement of cement matrices. There was a tremendous upsurge in research activities, in new forms and types of fibres and in a host of experimental applications in the two decades following the early 1960s. Even today, in the field of concrete materials technology, the amount of published material on FRC materials is possibly exceeded only by published papers on cement replacement materials.

Since those heady and hectic early days of the 60s it is no exaggeration to say that FRC materials have seen unprecedented development and acceptance during the following thirty and odd years. Today, a wide range of fibres varying in material composition and geometry, as well as many different types of FRC materials and commercial products are available for many *in situ* and precast applications. The most widely held view is, however, that fibres enhance the strength properties of the original cement matrix, although in reality, the increases in strength and elastic modulus are only marginal if fibres are stiffer than the cement matrix. With fibres less stiff than the cement matrix, substantial reductions in strength and elastic modulus may result, particularly if the fibres are used in volumes beyond an optimum. In spite of the very large amount of research on FRC, the real usage of the material in civil/structural engineering construction is very limited, compared to the vast amount of published material, and the question needs to be asked as to why this situation has come about? We need to ask ourselves a number of relevant and related questions if we are to unfathom this apparent contradiction, and the inverse relationship between research activity and practical applications.

Why do we add fibres to concrete?
What is the role of fibres in a cement matrix?
Is FRC cost-effective?
What do we expect FRC to give us that ordinary concrete with other types of reinforcing materials cannot give?
Is the short, discrete fibre the best geometry for all practical applications, where fibres can give a positive input to the properties of engineering materials?

We need to critically examine these and other related questions if we are to be able to put into much wider practice the very many technical advantages that FRC materials can offer to the construction industry.

Perhaps the unique property of the fibres embedded in a cement matrix is their ability to bridge cracks in the concrete, and thus restrict the cracks from widening and propagating. Fibres thus impart energy absorption, toughness and impact resistance properties to the FRC material, and these characteristics, in turn, improve the fracture and fatigue properties of FRC.

Enhanced toughness and impact resistance, relative to plain concrete, may thus be claimed to be the two key properties of FRC. Although these properties have received enormous attention in research and published papers during the last ten years or so, we seem to be at a loss to quantify these advantages in a manner that is realistic and competitive, and in a way that will be accepted by practising engineers, and indeed realised in practice. Toughness is not a property easy to define, but considered as their energy absorption capacity, it can be conventionally characterized by the area under some portion of the load–deflection curve obtained from a flexural test. The test methodology, its relevance to practice, and the interpretation of the test data are then obviously subject to fierce argument and debate. That fibres enhance energy absorption and toughness is beyond question, but how much of the laboratory-test value can be achieved in a large member in practice is dubious and highly questionable.

Other questions, similarly, hound the wider applications of FRC. How well do fibres control cracking during initial and final setting of the cement matrix? Are microfibres more effective than longer fibres, or vice versa? What governs their effectiveness? What about fire resistance and durability in alkaline environments, and stability when exposed to prolonged UV light? Are single filaments better in this respect than fibrillated bundles?

The world scenario offers the widest opportunities, but equally, the greatest challenge to scientists, engineers and concrete technologists in the use of fibre cement composites in the construction industry. Infrastructure construction and maintenance provide an unlimited scope for a wide range of applications where the unique properties of FRC materials can be used to the advantage of society, and to contribute to better the quality of living, but FRC materials need to be cost-effective and give durable performance. FRC materials, if they are to be considered to be of high performance, should give optimum service life for the load and exposure conditions for which they are designed, consistent with cost, quality and durability. Such composites may be reinforced with relatively cheap fibres, but for structural applications, metallic fibres and non-metallic stiff fibres alone can give the required strength and stiffness. Whilst short, discrete fibres can give excellent performance with conventional rebars, closely spaced and uniformly dispersed reinforcing elements can give outstanding crack control with enhancement of other engineering properties. Fibre reinforcement can also lead to new and innovative structural systems that are more efficient and cost-effective.

A much neglected area of FRC materials is the development of natural fibre cement composites. They pose the greatest challenge to engineers and material scientists, but they have special relevance to developing countries in view of their low cost, savings in energy, and their ready application to the rapid development of a country's infrastructure. Bamboo, for example, is one of the fastest-growing, highest-yielding and easily renewable of natural resources. To develop durable natural fibre cement composites needs a thorough understanding of material technologies and microstructure and their relationship to engineering behaviour — so does the development of cost-effective advanced composites and fibre reinforced plastics. The challenge is there — if only we can rise up to it for the betterment of society.