FIBRES CAN ADD SIGNIFICANT STRENGTH TO CONCRETE

By Jan De Beer

PRESS RELEASE

Including stiff natural or synthetic fibres in the concrete mix can significantly augment the strength of concrete, says Bryan Perrie, CEO of Cement & Concrete South Africa (CCSA).

Perrie says concrete made with Portland cement is relatively strong in compression but weak in tension which can be overcome not only by the usual insertion of conventional rod reinforcement but also by the inclusion of enough stiff fibres in the mix. In addition, the fibres alter the behaviour of the fibre-matrix composite after it has cracked, thereby improving its toughness.

Perrie says for the effective use of fibres in hardened concrete:

• The fibres must be significantly stiffer than the matrix;
* The fibre content must be adequate;
* There must be an excellent fibre-matrix bond; and
* The fibres must have a high aspect ratio, i.e. their length must be in the correct relation to their diameter.

There are natural and synthetic types of fibre, with steel and glass versions the most commonly used:

Steel:

Steel fibres have been used in concrete since the early 1900s. The early fibres were round and smooth, and the wire was cut or chopped to the required lengths. The use of straight, smooth fibres has primarily disappeared, and modern fibres have either rough surfaces and hooked ends or are crimped or undulated through their length.

Modern commercially available steel fibres are manufactured from drawn steel wire, slit sheet steel or by the melt-extraction process, producing fibres with a crescent-shaped cross-section.

“Typically, steel fibres have equivalent diameters (based on cross-sectional area) of from 0.15mm to 2mm and lengths from 7mm to 75mm,” Perrie states. “Carbon steels are most commonly used to produce fibres, but fibres made from corrosion-resistant alloys are available. In addition, stainless steel fibres have been used for high-temperature applications.”

Some fibres are collated into bundles using water-soluble glue to facilitate handling and mixing. Steel fibres have high tensile strength (0.5 – 2GPa) and modulus of elasticity (200GPa), a ductile/plastic stress-strain characteristic and low creep.

Steel fibres have been used in conventional concrete mixes, shotcrete and slurry-infiltrated fibre concrete. Typically, the content of steel fibre ranges from 0.25% to 2% by volume. “Fibre contents over 2% by volume generally result in poor workability and fibre distribution; it can be used successfully where the paste content of the mix is increased, and the size of coarse aggregate is not larger than about 10mm.”

Steel fibre-reinforced concrete containing up to 1.5% fibre by volume has been pumped successfully using 125 to 150 mm pipelines. In addition, steel fibre contents up to 2% by volume have been used in shotcrete applications using wet and dry processes.

“Steel fibre contents of up to 25% by volume have been obtained in slurry-infiltrated fibre concrete. Concretes containing steel fibre has been shown to substantially improve resistance to impact and show greater ductility of failure in compression, flexure and torsion. The elastic modulus in compression and modulus of rigidity in torsion is no different before cracking when compared with plain concrete tested under similar conditions. Because of its improved ductility, steel fibre-reinforced concrete could find applications where impact resistance is essential. Fatigue resistance of the concrete is reported to be increased by up to 70%.

“The inclusion of steel fibre as supplementary reinforcement in concrete could also assist in reducing spalling due to thermal shock and thermal gradients. However, the lack of corrosion resistance of normal steel fibres could be a disadvantage in exposed concrete situations where spalling and surface staining are likely to occur,” Perrie adds.

Glass:

In the form first used, glass fibres were found to be alkali reactive, and the products in which they were used deteriorated rapidly. However, alkali-resistant glass containing zirconia was successfully formulated in the 1960s and was soon in commercial production. Alkali-resistant glass fibre is used to manufacture glass-reinforced cement (GRC) products with a wide range of applications.

“Glass fibre is available in continuous or chopped lengths. Fibre lengths of up to 35mm are used in spray applications, and 25mm lengths are used in premix applications. GRC products are used extensively in agriculture, for architectural cladding and components, and small containers,” Perrie explains.

For further information, visit www.cemcon-sa.org.za.