ELSEVIER

Cement & Concrete Composites 26 (2004) 273–274

Cement & Concrete Composites

www.elsevier.com/locate/cemconcomp

Editorial

It is now universally recognised that global changes in technological revolutions and evolutionary industrialization combined with population growth and worldwide urbanization have resulted in the creation of a massive and horrendous *Infrastructure Crisis* that humanity has ever seen. The crisis is worldwide, and in the last few decades, it has been heavily fuelled by global warming, human conflict, wanton destruction, and the increasingly economic divide between the haves and the have-nots. The construction industry is the major "mentor" involved in the rehabilitation and regeneration of the world infrastructure, and because the construction industry is also closely interlinked with materials, energy and this planet's resources, *Sustainable Development* can prevent further environmental degradation, and thereby give hope for a better world order and better *Quality of Life* for all peoples of the world.

But *Sustainability in the Concrete and Construction Industry* is not a simplistic process, nor can it be achieved overnight. We can achieve *Sustainable Growth* only if the materials we manufacture and use, and the structures we design and build give durable performance for their specified design life, are cost-effective and environmentally friendly. *Lack of durability* is one of the greatest threats to sustainable growth. Unfortunately, we seem to think of *durability* only in terms of hostile environments or intrusion of aggressive ions such as sulfates and chlorides, or destructive material interactions such as alkali–silica reaction, freezing and thawing or delayed ettringite formation. We now know that *durability* must include not only *resistance to material degradation* but also *resistance to structural damage*, *brittle failure* and *progressive collapse* caused by unforeseen dynamic forces such as seismic action, floods, mud slides, hurricanes and tornados.

Sustainable growth thus demands that concrete construction should be seen as a *total and holistic activity* integrating material characteristics, structural performance, "DESIGN" as a total concept and construction. Structural innovations would then form as much an integral part of *holistic design* as material innovations, and structural ductility and integrity as important a criterion as material durability. Holistic design thus advocates a new design philosophy of *strength through durability* rather than *durability through strength*, and manufacture of materials and design of structures for *durability* rather than merely for *strength*. Holistic design will thus embrace the two basic concepts of *material stability* and *structural integrity and ductility*.

Flat slabs, a popular and economic form of construction with many practical advantages, are a case in point. These elements can often be subject to a major structural weakness characterised by a rather sudden and catastrophic type of brittle failure arising from punching shear. Many tests show that punching is a form of combined shearing and splitting, occurring without concrete crushing, under complex three dimensional stresses. Although the tension steel in the slab close to the column yields, especially when realistic reinforcement percentages are used, punching shear failure occurs in the compression zone before yielding extends beyond the vicinity of the column and before an overall yield mechanism can develop.

Steel fibre reinforcement, on the other hand, restrains cracking, and increases both the tensile strength of concrete, and the bond resistance of steel reinforcement. The main function of steel fibres is to control crack propagation and crack widening after the matrix has cracked. Control of cracking automatically enhances material and structural stiffness, and the non-linear post-cracking stage can impart the ability to absorb large amounts of energy before failure and collapse. Extensive studies show that fibres can act compositely with conventional steel bars, and that such fibre–bar interaction is synergistic. A direct result of these synergistic interactions is that fibres become very effective in resisting structural deformations at all stages of loading, from first crack to failure, resulting in a better distribution of cracks, control of penetration of shear cracks, and more extensive multiple cracking as failure approaches. It is this transformation of an inherently unstable and uncontrolled tensile cracking behaviour of concrete into a slow, controlled crack growth that is primarily responsible for the increased flexural rigidity, better structural performance and overall ductility of the structural member. The net result is that the slab is able to develop an overall yield mechanism which can transform a sudden structural failure into a

0958-9465/$ - see front matter
doi:10.1016/j.cemconcomp.2004.02.026

very ductile mode even if shear cracks appear at the failure stage.

Until recently, however, the use of steel fibre concrete to counteract brittle punching shear failures had been hampered by the absence of a reliable theoretical model and design equations. This is no longer the case. Existing code provisions do not account for the presence of fibre reinforcement in concrete, and they will therefore underestimate the ultimate loads of slabs with fibre reinforcement. There is now incontrovertible evidence that the new model and design equations are reliable, based on sound engineering principles, and reflect the true structural behaviour of slab–column connections. A critical evaluation of the structural behaviour of reinforced concrete slabs without or with fibre reinforcement and existing code provisions show that punching strength is not a simple function of concrete strength and the steel reinforcement ratio but a combined effect of the resistance offered by the shear and flexural sections of the slab.

Steel fibre concrete is an exciting construction material that possesses unique properties of high energy absorption capability and ductility. Its use in conjunction with flat slabs can lead to a new structural system having a high ultimate strength, characterized by a ductile mode of failure. Many tests on slab–column connections made with steel fibre concrete show that this new structural system can offer distinct advantages of structural integrity, structural stability and a high degree of ductility particularly when dynamic forces are involved.

R.N. Swamy
Department of Mechanical Engineering
University of Sheffield
Mappin Street, P.O. Box 600
Sheffield S1 3JD, UK
Tel.: +44-114-222-7712
Fax: +44-114-222-7890
E-mail address: r.n.swamy@sheffield.ac.uk