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# 2014/15 Undergraduate Research Grant Scheme

**Project title:** Steel Fibre Reinforced Self-Stressing Concrete (SFRSSC)

**University:** Loughborough University

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**Student:** tba

**Aims of research:**
The project aims to investigate experimentally and theoretically the performance of fibre reinforced concrete (FRC) in which the synergetic combination of CaO-based expansive admixtures and steel fibres induces a diffuse pre-stressing of the material at the micro-scale (as opposite to the macro-scale pre-stressing of concrete elements achieved with pre-tensioned or posttensioned bars and tendons). Cracking control and increased stiffness of small-bench specimens will be quantified, and the viability of this innovative approach will be assessed, also in comparison with the more expensive use of shape-memory alloy (SMA) fibres.

**Description of method:**
Steel fibres are added to the concrete mix as a diffuse reinforcement, with the aim to overcome the inherent brittleness of the material. As a result, the post-cracking behaviour improves and some pseudo-ductility is gained, while the tensile strength is not significantly affected. The latter would increase by pre-stretching the fibres, e.g. using shape-memory alloy (SMA) fibres, whose cost however is not compatible with large-scale civil engineering applications. An equivalent effect can be achieved through the expansion of the concrete matrix, e.g. using special expansive admixtures or special cements [1], that not only compensates the shrinkage of the material, but will also induce a self-balanced pre-stressing in the constituents (compression in the concrete and tension in the steel). Such micro-prestressed concrete would then enjoy enhanced tensile strength and significant pseudoductility, resulting in improved durability and better performance under monotonic and cyclic loads [2]. Experimental evidence is needed to prove the possibility to apply this concept for structural elements, and the effects of different parameters need to be investigated. In the proposed study, CaO-based admixtures will be used, and the concrete mix will be designed in such a way that the expansion takes place as a soon as a good matrix-fibre bond is established. Since optimal results are expected when the fibres provide a tri-dimensional constrain on the expansion, the effects of the distribution of the fibres will also be studied. For comparison purposes, the performance of self-compacting concrete made with SMAs will also be assessed. The proposed parametric study will be carried out through materials tests on concrete cubes and cylinders, along with displacement-controlled four-point bending tests on bench-size beams.

Key References.
[1] Meddah at al, Construction and Building Materials 25 (2011): 239-250.
[2] Wang et al, Advanced Materials Research 168-170 (2011): 1396-1399.

**Benefits to structural engineering:**
Significant improvements in terms of tensile strength and pseudo-ductility SFRSSC (steel fibre reinforced self-stressing concrete) will make it possible to reduce conventional reinforcement and to achieve better structural performance under different load conditions, both at the serviceability and at the ultimate limit state. Improved durability and more stable energy-dissipation cycles for earthquake engineering applications potentially appears as two of the most attractive features of such material.

**Proposed finish date:** May 2015