The Institution of Structural Engineers

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2012 MSc Research Grant Scheme

Project title: Prestressed ceramics

University: University of Cambridge

Supervisor: Dr Christopher Burgoyne

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Aims of research: Most engineers regard ceramics as brittle, and only available as small components, because they need to be fired. The objective is to demonstrate that ceramics can sustain large deformations, even after first cracks form, if they can be prestressed using techniques based on scaled down versions of those used in the concrete industry. The objective would be to make use of the ability of ceramics to withstand very high temperatures.

Description of method: Most attempts to toughen ceramics aim to improve the ceramic by inclusion of metal grains, silicon carbide fibres or by the adoption of very esoteric clays as precursors. This project uses very basic ceramics - offcuts from bathroom tiles. Narrow pieces (~50 mm wide) are cut from bathroom tiles and laid end to end on a metre long bed. Tensioned steel wires are then laid over the top of these tiles, together with a layer of epoxy adhesive. A second layer of tiles is then placed on top. The adhesive is allowed to set, and after about a day the prestress in the wires is released. The result is a pretensioned beam that can be loaded in bending, producing very significant deformations, both before and after cracking. This has been done in a previous project.

The objective of Anja's project is to extend this work by placing the prestress eccentrically (by placing two layers of tiles on one side of the tendon and one on the other, and to make beams that can be post-tensioned (by means of threaded rods and end plates) using tiles cut to form I- and T- and box beams. This will require more complicated cutting of the tiles which can be done using a water jet. Other extensions would allow the use of glass in place of the ceramics, aramid fibres in place of steel, or the cutting of shaped blocks to allow "chain of pearls" prestressing.

Benefits to structural engineering: There are many structural applications where high temperature resistance is desirable. Perhaps the most important is for the first set of turbine blades after the combustion chamber in jet engines. The temperature resistance of these blades governs the temperature at which the fuel is burnt, and is limited by the tensile strength of the metal blades. The use of ceramics, prestressed either internally or by an external ring, would allow higher temperatures to be used, which would result in higher efficiency. The purpose of this project is to demonstrate that prestressed ceramics are tough.

Proposed finish date: 06/2012