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STEEL FIBRE REINFORCED SELF COMPACTING CEMENTITIOUS (SFRSCC) COMPOSITE– TENSILE AND FLEXURAL RESPONSE

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TENSILE POST-CRACKING RESPONSE OF SFRCC

The use of Fibre Reinforced Cementitious Composites (FRCC) in structural applications is relatively a novel approach in order to overcome the tension weakness of concrete and its brittle behaviour. FRCC desirable particularity can be clearly distinguished by its tensile response either in “strain softening” (SS) or “strain hardening” (SH) post-cracking behaviour. A close form solution was proposed to calculate the moment-curvature response of FRCC section strengthened by longitudinal steel bars, in which, the tensile stress-strain behaviour of SS- and SH-FRCC was idealized by a three-linear curve (Fig. 1), while an elastic-perfectly plastic response is assumed for the compressive behaviour of FRCC and the tensile response of longitudinal reinforcement, respectively (Barros *et al.*, 2010).

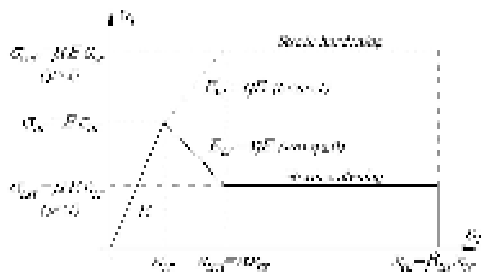

Figure 1: The idealized FRCC tensile stress-strain response in SS and SH behavoiur

A parametric study carried out on parameters utilized in the proposed model, to find the exact effects of each of them on bending moment carrying capacity of section (Taheri *et al.*, 2010). According to the obtained results, increasing the percentage of tensile longitudinal steel bars (ρ_s) in a FRCC section generally enhanced the bending capacity of section in both two different tensile post-cracking behaviors. Specially for the case of improvement of post-cracking tensile strength of FRCC in strain softening behavior, existence of higher percentage of steel in the section was almost neutralize the advantages of utilizing FRC materials with higher post-peak tensile strength (Fig. 2).

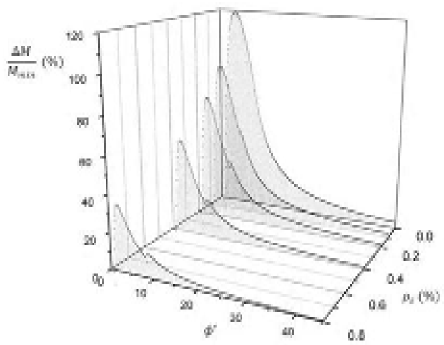

Figure 2: Differential resistant moment duo to curvature variation of SS-FRC beam $\Delta M = M_{\alpha=15} - M_{\min}$ and $M_{min} = M_{\alpha=1.01}$.

This clearly shows that increasing the content volume of fibers in FRC materials as an effective method for heightening the bending capacity of FRC section, losses its efficiency in existence of even low values of tensile steel percentage in cross section.

SELF COMPACTING CONCRETE

The addition of fibers to granular cement based materials perturbs its flowing ability in the fresh state. The optimum relation between fibres and aggregates can therefore be considered in mixture design by employing the concept of Self Compacting Concrete (SCC) with a high flowability and a moderate viscosity character. The subsequent researches showed that filling ability, resistance to segregation, and passing facility should be considered as key aspects of workability and satisfactory performance of SCC materials (Okamura and Ozawa, 1994).

MIX DESIGN FOR SS- AND SH-SFRSCC

The mix methodology already developed (Barros *et al.*, 2007) will be improved for its application to the development of SS- and SH- steel fibre reinforced self compacting cementitious composite (SFRSCC). The volume contents of 0.5, 0.75 and 1% of steel fibres will be explored for SS-SFRSCC, while the volume contents of 1.25, 1.5 and 2% of steel fibres will be used for SH-SFRSCC.

CHARACTERIZATION OF THE TENSILE AND FLEXURAL PROPERTIES

The stress-crack width relationship (σ-w) of the SS-SFRSCC will be determined carrying out uniaxial tensile test (UTT) with notched specimens. Since flexural tests are much easier, faster and not so expensive to execute than UTT, three-point notched beam bending test (3PNBBT) with SS-SFRSCC specimens will be executed to obtain the flexural stress versus crack mouth opening displacement (σ-CMOD). For the case of SH-SFRSCC, unnotched dog-bone type specimens, extracted from SH-SFRSCC panel will be carried out in order to obtain the tensile stress-strain (σ-ε) relationship up to the localization of the failure crack. Four-point unnutched beam bending test (4PUBBT) with SH-SFRSCC specimens will be also carried out in order to obtain the σ-ε from 4PUBBT. From inverse analysis (Cunha *et al.*, 2009) a methodology is established in order to obtain σ-w from the σ-CMOD and also the tensile σ-ε relationship from the σ-ε obtained from 4PUBBT for SS- and SH-SFRSCC, respectively.

FIBRE ORIENTATION FACTOR

It is well acknowledged that steel fibres have tendency to move toward bottom layers of cross section under the effect of gravity. The image analysis technique can be employed to obtain the fibre orientation factor (FOF) of section. On the other hand, the experimental program contemplates the evaluation of the σ-w relationship from specimens extracted from distinct depth along the cross section of a SS-SFRSC beam (Fig. 3) in order to establish a function that provides the residual tensile strength parameter ($\mu=\sigma_{cst}/\sigma_{cr}$, where σ_{cst} is the residual stress and σ_{cr} is the stress at crack initiation, Fig. 1) with the position along depth of the cross section, μ(z).

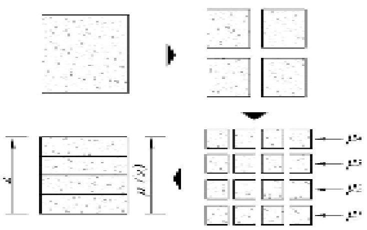

Figure 3: Evaluation of the residual tensile strength parameter (μ) for distinct

ANALYTICAL MODEL FOR THE SIMULATION OF THE BEHAVIOUR SS-SFRSCC LAMINAR STRUCTURES

The benefits of SS-SFRSCC use are explored in statically indeterminate structures. Utilizing the obtained σ-w response for SS-SFRSCC to simulate the post-cracking behaviour of layers that discretize the cross section of a laminar structure, the positive and negative moment-curvature relationship can be calculated, taking directly into account the effect of fibre orientation and distribution. Applying the yield line theory and adopting the design values for the constitutive law of the SFRSCC, the live load that can be applied for a certain suspended SFRSCC slab (like a slab supported on piles or columns) is estimated. Using this design methodology, parametric studies will be performed in order to determine the most competitive structural and material configurations for SS-SFRSCC suspended slabs.

NUMERICAL MODEL FOR THE SIMULATION OF THE BEHAVIOUR SH-SFRSCC COMPOSITE STRUCTURES

Material and structural potentialities of SH-SFRSCC are explored, mainly, in statically determinate innovative structural systems composed of thin SH-SFRSCC layers connected to glass fibre reinforced polymer (GFRP) profiles. A FEM-based elasto-plasticity approach, that includes the Drucker Prager and Mohr Coulomb yield surfaces, with the possibility of simulating SS- and SH-materials by using adequate functions for the cohesion and internal frictional angle of the material, recently implemented into FEMIX (Barros *et al*., 2009), will be explored to simulate the behaviour of SS- and SH-SFRSCC structures. After the constitutive model has been appraised, parametric studies will be carried out to optimize the material properties and structural arrangement of innovative, lightweight, durable and sustainable structural systems composed of SH-SFRSCC layers connected to GFRP profiles.

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