Semana de Engenharia 2010
Guimarães, 11 a 15 de Outubro

AN INTEGRAL APPROACH TO SIMULATE THE CREEP BEHAVIOUR OF STEEL FIBRE REINFORCED SELF-COMPACTING CONCRETE (SFRSCC) LAMINAR STRUCTURES

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KEYWORDS
Creep, fibre effectiveness index, SFRSCC

ABSTRACT

Fibre reinforcement is only effective after concrete cracking initiation, so creep of cracked SFRSCC can be a concern for accomplishing the requirements of long term deformability imposed by serviceability limit state. Therefore, a formulation to predict the long term deflection of cracked SFRSCC laminar structures is developed. Using advanced non destructive techniques, the fibre effectiveness index (FEI) that represents the distribution and orientation of the fibres is determined. Fibre pullout creep tests are executed to obtain the time-dependent force-slip relationship (F-s(t)), with fibres preliminary subjected to distinct slip levels in order to induce different bond damage conditions. From FEI and F-s(t) a stress crack width that integrates the creep effects is developed. Creep bending tests are carried out with four point notched beams (4PNB) with pre-crack of distinct width. Monotonic and cyclic 4PNB bending tests are also executed, as well as creep tests with prototypes of SFRSCC laminar structures.

INTRODUCTION

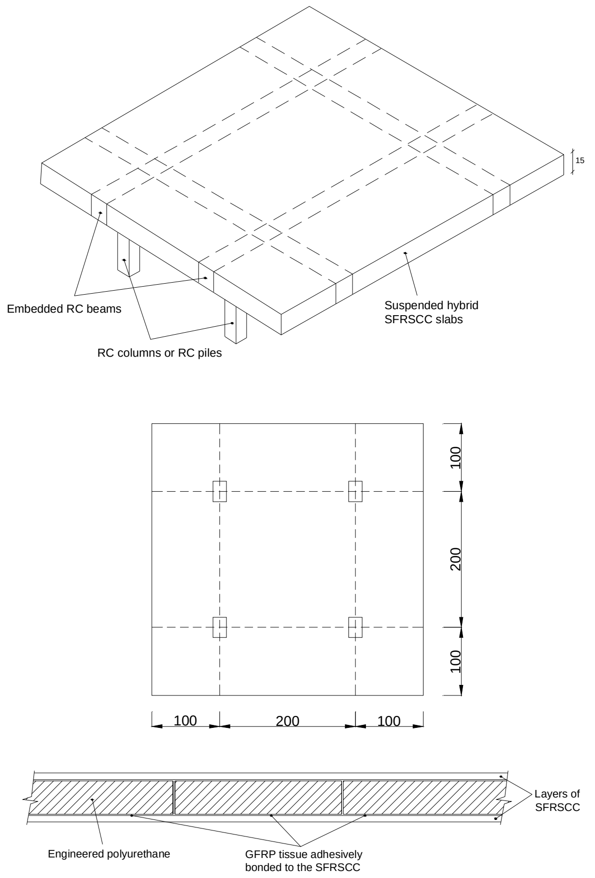
One of the most important properties of fibre reinforced concrete (FRC) is its ability to transfer stresses across a cracked section (fibre reinforcement effectiveness), which is dependent of the fibre orientation and fibre distribution (Vandewalle and Dupont 2003). The fibre effectiveness index (FEI) in the hardened-state is the final result of a series of stages that FRC passes from mixing to hardening state, namely (Oliveira 2010): fresh-state properties after mixing; casting conditions into the formwork; flowability characteristics; wall-effects introduced by the formwork. The evaluation of FEI allows establishing the stress-crack opening relationship that simulates the post-cracking behaviour of SFRSCC. To assess FEI, recently some advanced non-destructive techniques have been used, namely: computerized tomography (CT-scan); image analysis; X-ray method and alternating current-impedance spectroscopy (AC-IS).

For decades fibre pullout tests have been used to characterize and optimize the fibre reinforcement effectiveness (Cunha et al 2010). However, there is no comprehensive research on fibre pullout creep behaviour, which data and derived knowledge are fundamental for the development of a scientific-based model for the prediction of the creep behaviour of cracked SFRSCC laminar structures.

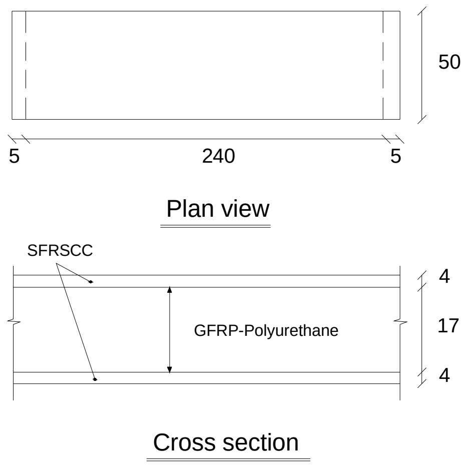
Creep is a term used to describe the tendency of materials to deform slow over time under a sustained load. These deformations may lead to excessive deflections that can compromise the serviceability of some structures. The creep in bending of cracked SFRC elements is the result of the following phenomena (Mackay and Trottier 2004, Barragán and Zerbino 2008): concrete creep in compression; fibres creep at material level in tension; loss of fibre-matrix adherence and subsequent fibre free-sliding.

EXPERIMENTAL PROGRAM

Fibre reinforcement is only effective after crack initiation of the matrix, and, therefore, creep of cracked SFRSCC can be a concern in terms of accomplishing the requirements of long term deformability of SFRSCC laminar structures (Figure 1). Consequently, the main objective is the development of a model to predict the long term deflection of cracked SFRSCC laminar structures. For this purpose the following sub-objectives need to be accomplished:



(a)



(b)

Figure 1 - a)suspended hybrid SFRSCC slabs; b)sandwich panels and slabs (dimensions in cm)

1) Evaluation of the FEI, since fibre reinforcement effectiveness depends of the distribution and orientation of fibres, which is the result of the phases that a SFRSCC has up to attain its final organization in a certain structure. FEI is determined by image analysis and alternating current-impedance spectroscopy.

2) Execution of fibre pullout creep tests, with fibres preliminary subjected to distinct slip limits in order to induce different bond damage conditions before the creep tests. A formulation based on the fibre pullout mechanisms is developed to define the Hi points that characterize the generalized force-slip diagram, F-s(t), (Figure 4). The effects of the fibre pullout creep, fibre bond length and fibre orientation in F-s(t) are assessed.

3) Evaluation of a stress-crack width relationship, σ-w(t), that takes into account both the creep behaviour of cracked SFRSCC subjected to bending and the knowledge derived from the two previous tasks.

4) Pre-cracked 4PNB of distinct width, subjected to environmental controlled conditions and submitted to distinct constant load levels, are carried out to evaluate the time-dependent evolution of crack width, w(t), and to appraise the predictive performance of the developed model.

5) SFRSCC laminar prototypes will be built, monitored and submitted to a constant load level that introduces an instantaneous w_{max}=0.3 mm. Results in terms of deflection and crack width evolution is used to appraise the predictive performance of the developed model.

REFERENCES

Barragán, B. E., & Zerbino, R. L. 2008. “Creep Behaviour of Cracked Steel Fibre Reinforced Concrete Beams”. Seventh International RILEM Symposium on Fibre Reinforced Concrete: Design and Applications.

Cunha, V.M.C.F.; Barros, J.A.O.; Sena-Cruz, J.M. 2010. “Pullout behaviour of steel fibres in self-compacting concrete”, ASCE Journal of Materials in Civil Engineering, 22(1).

Mackay J. and Trottier J.F. 2004. “Post-crack behavior of steel and synthetic frc under flexural creep”, in Proceedings 2nd Int Conference on Engineering Developments in Shotcrete, Australia.

Oliveira, F.L., 2010. “Design-oriented constitutive model for steel fiber reinforced concrete”. PhD thesis. Universitat Politècnica de Catalunya.

Vandewalle, L., Dupont, D. 2003. “Bending Test and Interpretation, Test and Design Methods for Steel Fibre reinforced Concrete - Background and Experiences”, RILEM publication PRO 31, Bagneux, 2003, pp. 1-14.

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