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HYBRID COMPOSITE PREFABRICATED (HCP) PANELS TO INCREASE THE STRENGTH AND ENERGY DISSIPATION CAPACITY OF RC MEMBERS

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High Performance Fiber Reinforced Concrete, Hybrid Composite, RC members strengthening.

ABSTRACT

Developing hybrid composite prefabricated (HCP) panels and exploring its applications for strengthening of RC members is the main objectives of the present project. The HCP thin panel is composed of a strain-hardening high performance fibre cementitious composite (HPFCC) reinforced with a polymeric grid (inside or bonded to external face of the panel). Using adhesive and bolts (optional) this panel is fixed to the structural element for strengthening purposes. The HPFCChas enhanced resistance to high temperatures, providing extra protection for resin adhesive and it gives extra protection to vandalism acts. Also the panel could produce enough stiffness for the bolting system to prevent significant stress concentration on the grid. Both experimental and numerical studies will be done to characterise the HCP panel behaviour and its applications.

INTRODUCTION

In the present research the new strengthening technique, to increase the flexural and the shear resistance, as well as the energy dissipation capacity of RC frames is exploring. This technique is based on the use of thin prefabricated panels of strain-hardening high performance fibre cementitious composite (HPFCC) that includes a polymeric grid bonded to the exterior surface of the panel or mounted inside it during production of the panel (Figure 1).

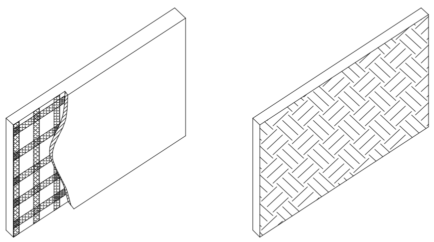


Figure 1: Hybrid composite prefabricated panels

The combination of HPFCC and polymeric grid results in a high toughness and strength panels that can be fixed by bolts to the element to strengthen, which allows the full exploitation of the strengthening potential of the materials forming the panel.

Engineered cementitious composites (ECC), a subcategory of HPFCC, is a synonym for ductile mortar and a design concept for micromechanics-based development of fibre reinforced cement based materials with outstanding performance in terms of fire protection, durability, energy absorption capacity, post-cracking resistance (Li 2008). ECC design concept is used to produce a ductile strain-hardening composite of cement, as a base material of HCP panel.

In the present research program the strengthening technique schematically represented in Figure 2 is investigated. The near surface mounting (NSM) technique is used to increase the negative bending moments of the hogging regions and the HCP panels are used to increase both the positive bending moments of the sagging regions and the shear resistance of the shear critical regions.

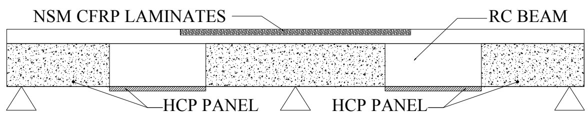


Figure 2: Strengthening technique for shear and flexure

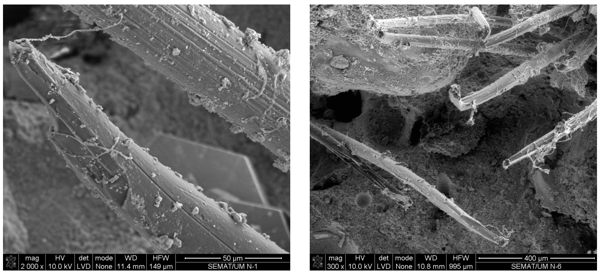
Another important objective of the present research is the development of a design guideline for the flexural and shear strengthening of continuous reinforced concrete beams, using the strengthening strategy schematically represented in Figure 2. For this purpose, the research includes an experimental program and the development of numerical tools able of predicting the behaviour of this type of structures.

Research Progress and the Obtained Results

Some experimental tests are done to develop ECC with the desired mechanical characteristics. For the first trial, some experimental tests were carried out to characterize the mechanical properties of ECC materials under flexure. Standard prisms for the characterization of the flexural properties of mortars were used.

The mix design is composed of cement, fly ash, limestone filler, sand, water, superplasicizer and

Polyvinyl Alcohol (PVA) fibres in one and two percent in volume of total mix. The out coming results evidence a flexural strain-hardening behaviour of tested prisms but without multiple cracking. Later using the scanning electron microscopy (SEM), it was found that the slip-hardening mechanism, in the fibers-matrix interface was not fully developed due to premature rupture of fibers. This is related to the strong chemical and interfacial bond, Figure 3.



Figures 3: Fibers' rupture mechanism in ECC

As it is shown in Figure 4, stress versus crack opening displacement was obtained from uniaxial tensile tests, in order to study the role of the fibers bridging a crack. This information will help to understand the overall strain behavior of ECC during multiple cracking stages and will be useful for numerical simulation.

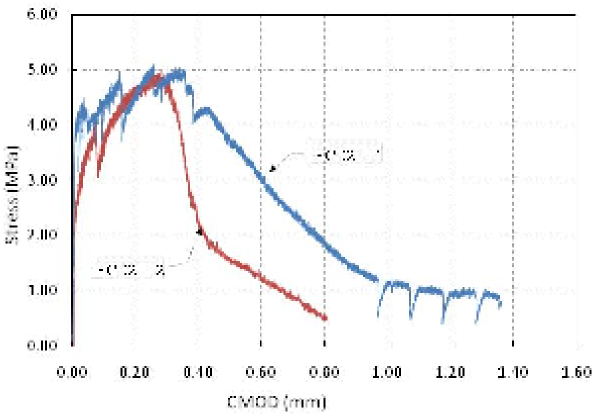


Figure 4: Tensile stress-crack opening test results

To obtain global behaviour of ECC under monotonic, direct-tensile load configuration with a dog bone shape specimen was selected to measure total elongation (strain ductility) and verify the possibility of forming diffuse crack patterns. The results of test showed a multiple crack pattern with maximum strain ductility around 0.7% (Figure 5).

Low workability and low strain capacity are two major problems faced in developing ECC using polymeric fibers. In the current stage, to increase the workability and assure better fibre dispersion, modification of the rheological characteristics of the mix is under study. Different types of superplasticizers and viscosity modifiers are being used. To measure the deformability and viscosity (flowability) mini slump and V-funnel tests are being performed, respectively. A certain amount of viscosity is necessary to improve the dispersion of fibres and avoid segregation. As a result of some trials, a mix with 180 mm diameter of mini slump test and a flow rate of 11 seconds in the V-funnel test was developed. These values are in the range of a self compacting mortar. It should be noted that to insure the self-levelling, L-box test should be essentially done (Ozawa el al. 1995).

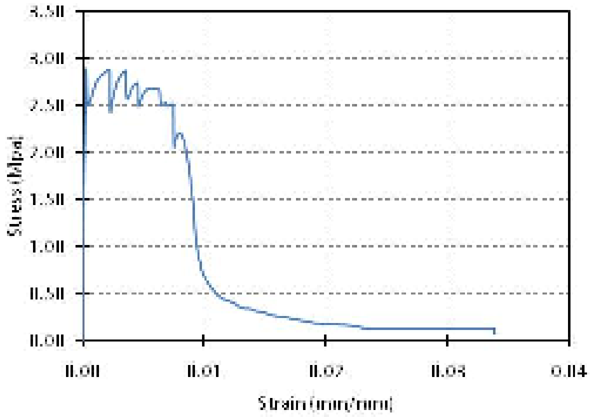


Figure 5: Tensile strain_hardening behavior of ECC

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