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EMBEDMENT OF STEEL BARS FOR THE SHEAR STRENGTHENING OF CONCRETE ELEMENTS

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Shear strengthening, ETS technique, beams, slabs.

ABSTRACT

An ongoing experimental program formed by continuous slab strips strengthened in flexure with NSM CFRP laminates is being carried out, and the obtained results show the possibility of increasing significantly the load carrying capacity of these elements, maintaining high levels of ductility. However, the occurrence of shear failure in the continuous slab strips limits the efficacy of the NSM technique. In case of slabs, the NSM shear strengthening has no applicability, and a strengthening strategy that avoids the occurrence of shear failure and provides extra resistance to the detachment of the NSM laminates is proposed in this work. According to the strengthening strategy, holes are opened across the slab/beam thickness, with the desired inclinations, and bars are introduced into these holes and bonded to the concrete substrate with adhesive materials. To assess the effectiveness of this technique, an experimental program was carried and the results confirm the feasibility of the proposed technique.

INTRODUCTION

Limited researcher has been conducted on the use of embedded bars for shear strengthening. Chaalal et al. (2011) and Valerio et al. (2005, 2009) performed some tests and the results show the efficacy of the proposed technique in the shear strengthening of RC beams. In this context, the potentialities of the of the Embedded Through-Section (ETS) are explored for the increase of the shear resistance of RC beams. A description of the carried out experimental research and a discussion of the obtained results are done in the present paper.

EXPERIMENTAL PROGRAM

The experimental program is formed by two series, A and B, composed of beams with a cross section of 150x300 mm^2 and 300x300mm^2, respectively, with a total length of 2450 mm and a shear span length of 900 mm. Each series is made up of a beam without any shear reinforcement (Reference) and a beam for each of the shear strengthening configuration, as presented in Figure 1.

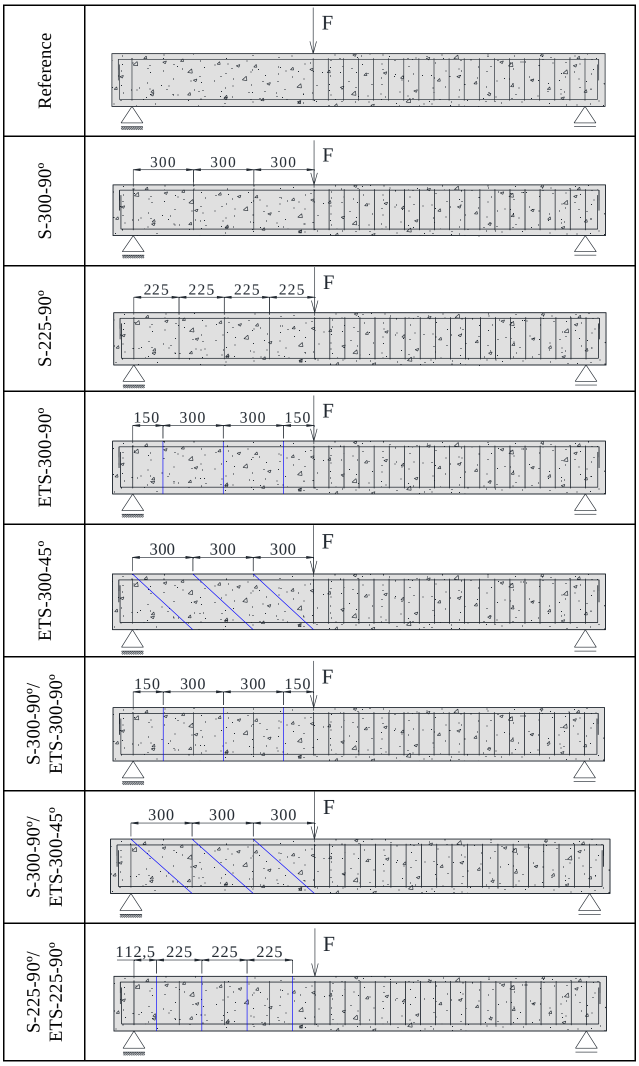

Figure 1: Shear strengthening arrangements

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RESULTS OF THE EXPERIMENTAL PROGRAM

The applied loads versus deflection curves of the tested RC beams of the A Series are presented in Figure 2. It can be noted that the use of embedded steel bars allowed significant increment of the shear resistance of reinforced concrete beams, regardless of the orientation of the bar. The effectiveness is not only in terms of the beam load carrying capacity, but also in terms of the ductility of the beam's.

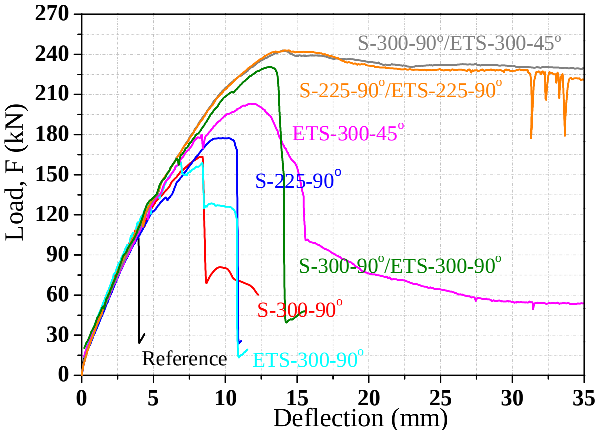

Figure 2: Relationship between the applied load versus the loaded section deflection

From the results obtained it can be pointed out the following main observations:

(i) The shear reinforcing system composed by inclined strengthening bars was more effective than vertical bars, assuring a better performance in terms of shear resistance and deflection capacity.

(ii) The ETS shear strengthening technique can convert a brittle shear failure in a ductile flexural failure.

(iii) The maximum load and the deflection capacity of the beams reinforced with conventional stirrups were similar to the values registered on beams strengthened with ETS bars. Thus, it was verified the feasibility of using the ETS bars to correct construction/design deficiencies, strengthening or rehabilitation of structures that become unsafe due to changes in loading, use, configuration or seismic actions.

(iv) The ETS shear strengthening elements have higher protection against fire and vandalism acts than FRP systems applied according to the externally bonded reinforcing (EBR) or Near Surface Mounted (NSM) techniques. Additionally, this shear reinforcing system is also easier and faster to apply when compared to the EBR and NSM techniques.

CONCLUSIONS

This study presents some of the results of an experimental investigation on the behavior of reinforced concrete beams strengthened in shear according to the ETS technique. According to the results it was verified the feasibility of using the proposed shear strengthening technique, since shear brittle failure mode can be avoided, resulting significant increases in load carrying and deformational capacities of the strengthened elements. Furthermore, appreciable levels of residual strength after the peak load were obtained.

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