NUMERICAL MODELLING OF THE PUNCHING BEHAVIOUR OF STEEL FIBRE REINFORCED SELF-COMPACTING CONCRETE FLAT SLABS

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Abstract

In this work are presented and discussed the results of punching shear tests carried out on flat slabs with a hybrid reinforcement (rebar + discrete fibres). Four half scaled slabs, reinforced with distinct fibre contents, namely, 0, 60, 75 and 90 kg/m^3 were tested. The experimental results were numerically modelled within the FEM framework.

Keywords: Flat Slab, SFRSCC, Punching Shear, Numerical Simulations

1. Introduction

The design of flat slabs is mostly governed by both serviceability conditions, namely quite high deflections in service, and ultimate limit states under punching shear. The adopted suspended flat slabs structural system (slabs supported on RC columns) might be prone to punching shear failure, as a consequence of the small slab thickness and absence of chapiters to ease up the transfer of forces from the slab to the column. Moreover, traditional stirrups as shear reinforcement are unsuitable for slabs with shallow depth less than 150 mm.

2. Experimental and Numerical Results

The punching tests of the slabs were carried out by applying an upward loading direction at the centre of the slab. It was used an actuator of 1000 kN capacity. Between the actuator and the bottom surface of the slab, in the central part of the slab, a steel plate was used to distribute, as uniform as possible, the load applied by the actuator. The test was executed under displacement control, at a displacement rate of 0.05 mm/min in the centre point of

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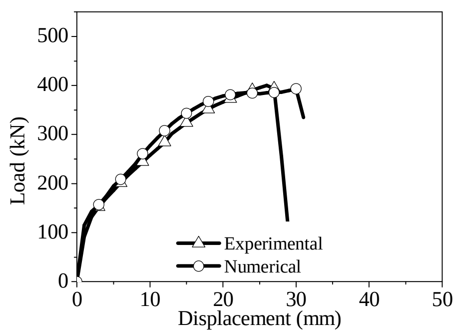
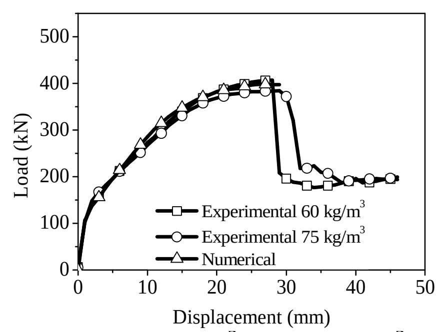
the slab. It should be mentioned that the *Cf60fc50* and *Cf75fc50* slabs it was verified that fibres had fallen down from the treadmill during the transportation procedure of the fibres to the mixer and the content of fibres was approximately the same in both slabs.

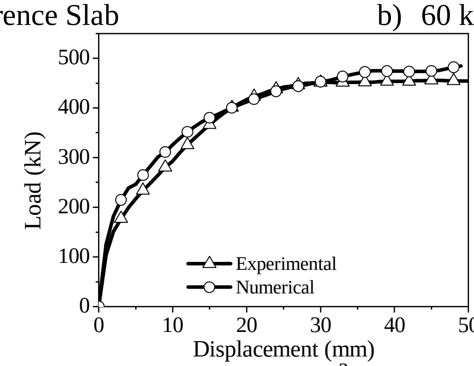
Fig. 1 depicts both the experimental and numerical results of the flat slabs. In general, it is possible to notice that the numerical simulations are in good accordance with the experimental curves. Concerning the numerical simulation of the *Cf0fc50* slab, it was predicted the punching shear failure, however the displacement for which this type of failure occurs was slight overestimated, approximately 10%. On the other hand, for the *Cf60fc50* and *Cf75fc50* series the load decay observed experimentally due to punching was not captured experimentally due to difficulties on the convergence process of the numerical simulations of both slabs. However, the deformational response was predicted with high accuracy, and since convergence was not possible to assure precisely at the deflection level coinciding with the punching failure observed experimentally it is presumed that the model is almost in the situation of capturing this type of failure mode. Finally, in the *Cf90fc50* series, both the experimental and numerical curves are almost coincident in all their length. Neither of them shows a punching failure, due to the high fibre content used in this series.



a) Reference Slab



b) 60 kg/m^3 and 75 kg/m^3



c) 90 kg/m^3

Fig. 1: Experimental and numerical results

3. Conclusions

Regarding the experimental results, a clear tendency of an increase of the load carrying capacity of the slabs with the increase of $f_{R,I}$ obtained from three-point bending tests was observed. This evidences that the corresponding post-cracking residual strength parameters provide good indicators in terms of slab's load carrying capacity, since a linear trend between these parameters is observed. The load-deflection curves obtained in the numerical simulations are in good accordance with the experimental ones. Moreover, the type of failure mode observed on the experimental tests was also successfully predicted.