

HIPERSLAB – Enhancement of the Structural Behaviour of Flat Slabs under Cyclic and Seismic Actions through the Rational Use of High Performance Fibre Reinforced Concrete

Summary

Flat slab buildings for commercial, office and residential use are a common solution in Portugal, as well as in many other countries. Nevertheless, its behaviour under gravity and seismic actions is still not very well understood by the scientific community. The EuroCode EN1998.1, prescribes in 5.1.1(2)P: "Concrete buildings with flat slab frames used as primary seismic elements in accordance with 4.2.2 are not fully covered" by the EC8 section on concrete structures. This statement results from the lack of knowledge about the stiffness of the slab-column connection and the brittleness of the punching failure. It is also the consequence of insufficient knowledge about the behaviour of flat slabs under seismic actions and the need for further research on the punching behaviour and resistance under cyclic and dynamic horizontal loading.

High and Ultra High Performance Fibre Reinforced Concrete (HPFRC and UHPFRC) are relatively recent materials that presents higher durability and mechanical resistance when compared to Normal strength concrete (NSC). These high-performance materials give the opportunity to design slender, lighter, elegant and efficient structures. Another innovative aspect of the use of these materials, associated with slenderer structures, is the use of less amounts of raw materials in its manufacture, with less environment impact. However, insufficient established design rules have been obstacles to a larger use of HPFRC and UHPFRC in structural design. Being more costly materials, when compared with the NSC, it is also imperative to study its rational structural use. One of our objectives is the use of HPFRC and UHPFRC in localized areas at the slab-column connection, being the remnant slab cast with NSC. This way we can minimize the economic impact of using the HPFRC/UHPFRC and enhance its competitiveness.

The project was divided into three main phases. In a preliminary phase the HPFRC and UHPFRC were developed and characterized. Afterwards, some punching tests of flat slab-column connections under vertical monotonic loading were performed, to access the potential benefits of different geometry layouts, with the localized and rational use of HPFRC/UHPFRC. Five slab specimens, with 2200x2200 mm and 150mm tick, were produced and tested.

Subsequently, some more tests were performed under reversed cyclic horizontal actions until failure, to better understand the behaviour of this kind of structures under earthquake induced deformations. Four specimens measuring 4.15 m x 1.85 m with a thickness of 150 mm (Fig. 2) were tested under combined gravity loading and imposed reversed horizontal cyclic drifts. The

experimental tests were accompanied with non-linear numerical modelling of the column-slab connections, and subsequently a parametric analysis, due to lower costs and preparation time, and the possibility to analyse a higher number of cases with FEA than with experimental tests.

The research proposed in this project aims to increase the knowledge on the behaviour of HPFRC/UHPFRC structures. It also has the purpose to suggest design recommendations for safer structures, particularly under seismic actions. The research is strong-minded in the safety of people and in the economy of the construction industry.

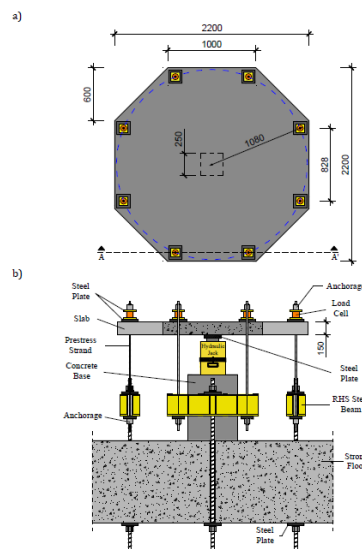


Figure 1. Test setup for the monotonic punching tests (dimensions in mm).

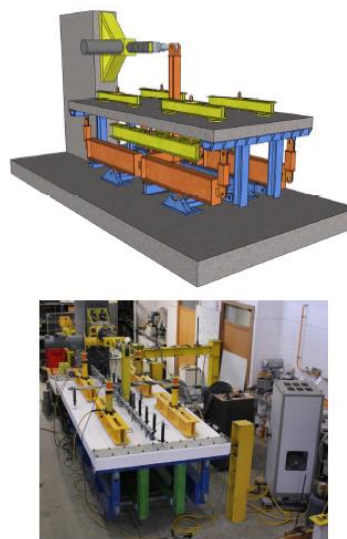


Figure 2. Test setup for the cyclic punching tests.

Project Reference

PTDC/ECI-EST/30511/2017

Leading Institution

NOVA.ID.FCT – Associação para a Inovação e Desenvolvimento da FCT (Portugal)

Partners

FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal), IST-ID – Associação do Instituto Superior Técnico para a Investigação e Desenvolvimentos (Portugal)

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CERIS

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Project Website

sites.fct.unl.pt/hiperslab