CERIS : Civil Engineering Research and Innovation for Sustainability

Seismic behaviour of flat slabs with punching shear reinforcement

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Summary

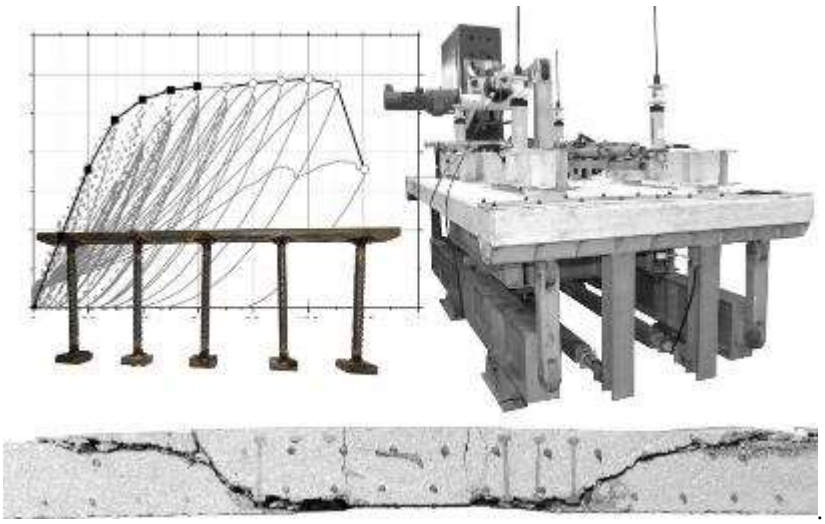
Flat slabs have found widespread use in buildings over the last decades. They owe their popularity to several advantages, including construction cost and speed, as well as convenience in architectural design. Traditionally designed as gravity load carrying systems, flat slabs are found even in earthquake prone areas. When subjected to horizontal drifts, flat slab–column connections are susceptible to brittle punching shear failure, which results in a sudden drop of the load carrying capacity. Especially in Europe, the designers are faced with difficulties arising from the lack of a full coverage by the codes. Past experimental research has shown that the drift capacity of flat slabs can be significantly enhanced when punching shear reinforcement is used. This dissertation provides insight on the factors that influence the deformation capacity and the role of the enhancement of this capacity in the seismic behaviour of buildings with flat slabs.

An experimental campaign containing five reinforced concrete flat slab specimens (four of which reinforced with headed shear studs) tested under constant gravity loads and reversed horizontal cyclic displacements constitutes the core of the dissertation. It is shown that the ultimate drifts are described reasonably well if the following factors are taken into account simultaneously: the gravity load, the punching shear resistance, flexural strength and the extent of shear reinforcement. Although the main focus is on secondary seismic flat slabs (that do not take part in the earthquake resisting system), a contribution is made towards better understanding the behaviour and limitations of flat slabs as primary seismic elements, which are intended to be included in the new generation of Eurocodes.

The role of punching shear reinforcement in the global behaviour of such buildings is studied through a series of nonlinear analyses, which show that properly designed punching shear reinforcement can enhance both safety and robustness. It is shown that the inherent high flexibility of slab–column connections remains a limitation for primary flat slabs, even when shear reinforcement is provided

Keywords

Flat slab, punching, seismic behaviour, cyclic loading, studs.



Headed studs as punching shear reinforcement in slab-column connections under lateral loading: test setup, a saw-cut and typical response.