

Abstract

Punching shear reinforcement is an efficient method to increase not only the strength but also the deformation capacity of flat slabs supported by columns. Especially, the increase in deformation capacity is desired so that the load can be distributed to other supports preventing a total collapse of the structure in the case of the occurrence of a local failure. Thus, the research presented herein addresses the punching strength as well as the deformation capacity of flat slabs. Thereby, the focus is set on the analysis of the maximum increase in strength and rotation capacity due to punching shear reinforcement. Therefore, the principal aim is the analysis of flat slabs with large amounts of punching shear reinforcement. In addition to an experimental and numerical investigation of flat slabs, another principal objective of the research project was the development of an analytical model that enables accurate predictions of the punching strength and the rotation capacity of flat slabs with large amounts of shear reinforcement. Thus, the research presented herein can basically be divided into three main parts.

An experimental investigation of sixteen flat slab specimens with and without shear reinforcement leads to new findings with respect to the punching strength and the load-deformation response of flat slabs. The results of the tests serve for the validation of current design codes and the Critical Shear Crack Theory. In addition to the specimens tested within this research project, tests found in literature are used to investigate the influence of certain parameters on the prediction of the punching strength.

A non-linear numerical model on the basis of the Finite Element Method enables the modeling of the test specimens. This approach uses plane stress fields to calculate the moment-curvature response of a discrete slab element. The thereby obtained flexural and torsional stiffness serve as input parameters for a linear-elastic finite element analysis. This analysis enables the modeling of the load-deformation response of the tested slab specimens leading to valuable information regarding the state of deformation at different load levels.

The findings of the experimental and the numerical investigation support the development of an analytical model. The theoretical background of this model is the Critical Shear Crack Theory, which describes the punching strength as a function of the slab rotation. Thus, the developed analytical model enables the calculation of the load-rotation response of flat slab specimens. Moreover, the developed failure criteria enable the prediction of the punching strength as well as the maximum rotation capacity. Finally, it is shown that the results obtained from the developed model are in good agreement with results of tests performed within this research project and of tests found in literature.

Keywords: punching shear, shear reinforcement, flat slabs, flexural response