

# Numerical Analysis of Punching Shear Failure of Reinforced Concrete Slabs

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**Abstract:** *Nearly no load bearing behaviour of reinforced concrete members allows such varied interpretations and complex discussions as the shear behaviour. Especially the three-dimensional problem of the punching shear failure of reinforced concrete members is internationally discussed. Nevertheless up to now, there is no unified design approach or even an overall accepted design model. Especially for large structural members, as they are commonly used in industrial structures and high-rise structures, the experimental background is missing. Because of extensive costs and very high test loads numerical solutions and FE-simulations are indispensable. By using Abaqus, finite-element simulations are currently performed at the institute for reinforced and prestressed concrete structures at the Ruhr-University Bochum. For the main investigation of the punching shear problem, the general conditions as well as the applicability of the constitutive law and the discretization have to be investigated, proved and verified first. The main goals of these preliminary investigations are the determination of influences of different element types, the discretization of the reinforcement and the size effects of the used material model. The concrete is modelled by 8-nodes or 20-nodes solid continuum elements. Regarding the concrete material behaviour, a non-linear user-defined material model based on the concrete damaged plasticity model is used. For the parametric study, small and medium-sized slabs are simulated for comparison and verification with experimental data to ensure realistic results of the large-sized structures. The article will report the latest results of these simulations and the special problems of simulating the punching shear failure of reinforced concrete slabs.*

**Keywords:** *Concrete, Constitutive Model, Damage, Experimental Verification, Failure, Fracture.*

## 1. Introduction

The actual German and European code provisions for the design and construction of reinforced concrete slabs against punching shear failure base on semi-empirically and statistically developed formulations. Although there are different models and approaches available that try to describe and explain the punching shear behaviour and failure, even nowadays formulations and design parameters for punching have to be found by experimental analysis.

In this context the empirical background is generally derived from small-scale tests. Usually, experimental data for punching shear failure can be found for slab thicknesses smaller than around 30.0 cm (CEB-FIP, 1993).