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Numerical Model on the Example of Experimental Investigations of a Punching in the Central Connection of the Slab with the Column Situated Eccentrically

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Abstract: The topics of punching in slab-column connections of reinforced concrete structures are particularly important due to the safety of their exploit. The paper presents a spatial numerical model of connection between the slab and the column, where the column is situated eccentrically to the surface of the slab. The geometric and material parameters adapted in the numerical model were the same as in the experimental model. The numerical model bases on predefined material models of steel and concrete, taking into account non-linear dependences of the strength of these materials. The obtained results of calculations based on a numerical model have been compared with results of experimental investigations.

Introduction

In the light of previous studies, the design principles of support zones of the slab-column structures have been developed. However, the work of this type of structures in the range of loads close to destructive loads needs to be precisely understood due to their consequences for the safety of people. The primary aim is to prevent the possibility of progressive collapse in the event of a local damage of structure. Some suggested solutions in this scope have been mentioned only in Model Code 2010, ACI 318 and CSA A23.3.

The current development of computer methods aided the calculations using finite-element method and allows a more precise determination of internal forces in the support zone, where bending moments and shear forces are concentrated. In order to determine the value of the load capacity of the support zones to puncture, the numerical model of the slab and column connection was developed. Apart from the two parallel reinforcing meshes at the upper and bottom surface of the slab, additional bottom reinforcing bars crossing directly over the column have been used, according to recommendations [1].

Description of the numerical model

The numerical model has been developed on the basis of experimental research [2] concerning the central slab-column connection in which an extra recommended reinforcement securing the structure against a failure has been installed. The test model (Fig.1) consisted of a 20 cm thick square slab with the dimensions 2.65×2.65 m and 50 cm high bottom square-section column with the dimensions 40×40 cm. The reinforcement of the model consisted of the two parallel reinforcing meshes at the upper and bottom surface of the slab. A detailed description of the model and the test stand along with the test course description can be found in paper [2].

The numerical analysis was conducted using the *ANSYS* system. The numerical simulation of the slab-column connection has been conducted using Solid65, 8-node 3D finite elements. In the conducted analysis the behaviour of concrete was described using a multi-parameter material model Concrete. The model of slab reinforcement has been developed in a discrete way using 2-node bars Beam188. In order to reflect the behaviour of reinforcing steel a non-elastic model with isotropic reinforcement has been applied. The parameters of the model have been described using von Misses criteria. The analysis assumes a full cooperation between linear reinforcement elements and 3D concrete elements by assuming the compatibility of the displacement of the nodes. The parameters of concrete and steel models have been applied on the basis of material tests which can be found in [2], [3].

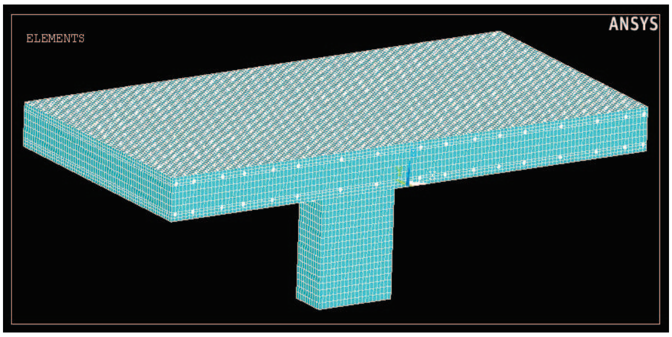

Fig. 1: View of the cross section in the numerical model – ½ of the model

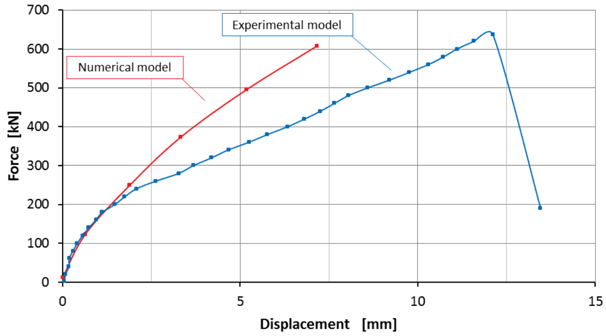

Fig. 2: Values of vertical displacements in the centre of slab in the function of the load

Synthesis of the results

The numerical simulations reflecting the laboratory tests of the model presented in paper [2] allowed to obtain, e.g., a comparison of values of the vertical displacement of the upper surface. Fig. 2 presents the comparison of the load-displacement relationship obtained through a numerical simulation with an experimental curve. It can be observed that theoretical prediction of the limit load of 607.7 kN is fairly consistent with experimental results where the punching force was 637.2 kN.

Summary

Despite small differences obtained during experimental research and numerical analysis it can be stated that numerical simulation allows to represent the existing knowledge about punching. The obtained quantitative results are similar to previous strength analyses. The 4.6% difference between values of the forces can arise from the lack of a perfect mapping of mechanical parameters of concrete and steel. The numerical simulation represents a considerably higher stiffness than in the real experimental model. Therefore depending on the level of load values, the significant differences in the value of displacements for both models were obtained.

References

[1] ACI-ASCE Committee 352, Recommendations for design of slab-column connections in monolithic reinforced concrete structures, 1988.

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