REINFORCED CONCRETE SLAB WITH SUBSOIL: NUMERICAL MODELLING AND EXPERIMENT

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Abstract

The paper is focused on the issue of modelling reinforced concrete slab in the interaction with the subsoil. It is a specific task that includes the design of concrete structure and geotechnical analysis. The aim of the paper is to analyze the effects of parameters of subsoil in nonlinear analysis. Specifically, a parametric study for different subsoil depths and subsoil modulus of elasticity is elaborated. For numerical modelling, an experiment of the reinforced concrete slab with dimensions of 2000 x 2000 mm and thickness of 150 mm was chosen, which was tested on a specialized device at Technical University of Ostrava. The concrete slab is reinforced with steel reinforcement. Nonlinear analysis with utilization of finite element method is chosen to solve the 3D numerical model, where the fracture-plastic material model is chosen for concrete.

Introduction

Soil Structure Interaction (SSI) includes research two area, i.e. design and analysis of concrete structure (Hegger, J. et al., 2006) and geotechnics - subsoil analysis (Hrubesova, E., et al., 2018 and Padera, et al. 2019). SSI is particularly important in the case of specific foundation conditions or subsoil, extreme load (Kralik, 2016) or dynamic analysis (Kotrasova, 2017). For this reason, knowledge of the manner of failure (Silburg, et al., 2014 and Sucharda, et al., 2018) and the possibilities of using advanced computational models (Caďka, 2014 and Tomasovcova, et al. 2017) are important. In the field of SSI research, attention is paid mainly to experimental research, which is focused on shear failure in concrete structures (Hegger, et al., 2007 and Buchda, et al. 2015). However, the solution is only suitable for simple selected tasks. In particular, however, numerical modelling is developing (Cervenka, et al., 2016). In the detailed SSI analysis, it is necessary to take into account the choice of a computational model, subsoil stiffness, interaction modelling and interface and subsoil between these systems. Also important is the choice of a concrete model that takes into account cracking and shear failure or punching. In summary, this to the use of nonlinear analysis and finite element method.

Numerical modelling

The performed study is based on a non-linear analysis involving a 3D computational model with a loading steel plate, reinforced concrete slab and subsoil. The calculations are conducted for a variable subsoil depth of 2 to 6 m and a modulus of subsoil elasticity of 10 to 30 MPa. The finite element mesh has a regular shape. Computer model and boundary conditions are shown in Fig. 1. The detail of the finite element mesh is shown in Fig. 2. The ground plan size of the model was 6 x 6 m. Concrete parameters respect to Model Code 2010 and user manual Atena (Cervenka, et al., 2016). A contact interface is modeled between the concrete slab and subsoil. The load was applied by force in steps of 10 kN. In the Fig. 3 there is graphic output of crack occurrence and stress on the slab.

Conclusions

In tab. 1 is shown the deformations for individual variants of the calculation with the numerical models, which have different modulus of elasticity of the subsoil and different depth of subsoil. The results show a greater influence of deformations when changing the modulus of elasticity of the subsoil than when changing the depth of the subsoil. The numerical deformations are significantly smaller when the modulus of elasticity of the subsoil increases.

For a load of 750 kN, the difference is even more pronounced from 12.32 to 40.02 mm. Is evident influence of the development of cracks in the concrete and reduction of the bending stiffness of the concrete slab.

Table 1. Deformations of reinforced concrete slab – parametric study.

<table>
<thead>
<tr>
<th>Subsoil depth (m)</th>
<th>Load (kN)</th>
<th>2</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25</td>
<td>8.60</td>
<td>9.50</td>
<td>10.91</td>
<td>40.02</td>
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<tr>
<td>4.25</td>
<td>3.68</td>
<td>4.00</td>
<td>4.64</td>
<td>14.60</td>
</tr>
<tr>
<td>32.5</td>
<td>3.92</td>
<td>12.32</td>
<td>4.44</td>
<td>13.62</td>
</tr>
</tbody>
</table>

References

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