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NUMERICAL ANALYSIS OF THE APPROACH SLAB EXPERIMENT FOR PARAMETRICAL STUDY

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Abstract: *The approach slab function is to overcome the transition between the abutment and the soil embankment. The issue is in the different stiffness of those elements and its foundation, what causes the differential settlement. The main goal of this work is to optimise the numerical analysis of the prepared experiment of the approach slab according to the results of experiment itself. The task is not only in getting nonlinear material characteristic of the soil, or the concrete material of the slab, but also in the accurate representation of the behaviour when cyclic load is applied. This type of loading represents the load implicated by the vehicle passing. The correct adjusting of the numerical model could lead to further parametrical study of the whole transition zone in full scale.*

Keywords: **approach slab, transition zone, non-linear time-step analysis, bridge abutment, embankment**

1. Introduction

The approach slab is designed to compensate the different settlement of the bridge abutment and a road embankment. In Fig. 1 the typical cross section of the transition zone represented by FEM model can be seen. It is prepared for the parametric study. Main subject of the interest is the difference in stiffness of the foundation.

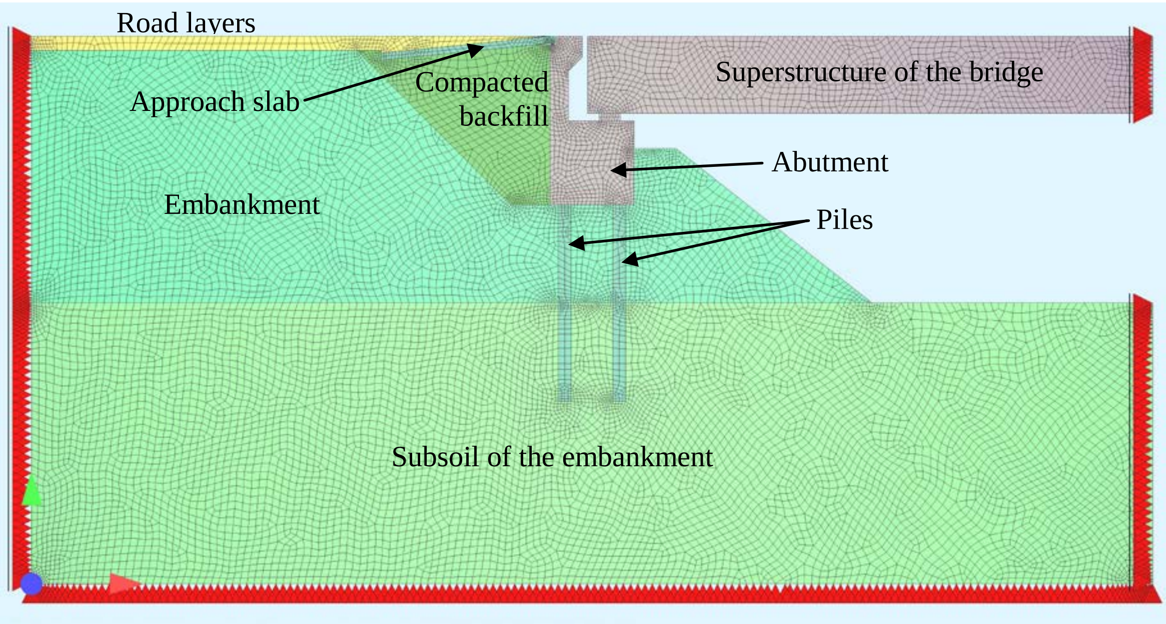

Fig. 1: FEM model of the transition zone typical cross-section.

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Driving comfort can be interrupted by the so called “bump” on both ends of the bridge. These disorders caused by the exceeded size of the different settlements should be eliminated by the approach slabs. Among many reasons of the uneven settlement the most common ones are the consolidation of the soil embankment and its subsoil.

2. Structural Model of the Approach Slab

For the estimation of the structural member behaviour, proper structural scheme should be used. The simplest, but also the most conservative model is represented by simple supported slab, with hinges on both ends. One in the place of connection to abutment. The other, at free end in specific distance according to resultant of the bedding pressure. Conservative model is assumed in Slovak standard (OTN 73 6244, 1981).

More precise schemes include elastic support under the slab, whether along the whole length, or only partially at the free end. Stiffness of this support beneath the slab can also develop in time. Problem with right structural description comes with the type of acting load. Behaviour of the approach slab is changing in time with consolidation of the backfill, embankment or subsoil, or by any accidental situation such as soil erosion resulting in void development in mid-span of the slab. Detailed study comparing various models was already published in Laco, Borzovič and Panuška (2014)

In this paper the nonlinear analysis with the nonlinear soil and concrete parameter was performed. Despite the accuracy of this type of analysis, its usage is limited only for the scientific or experimental works. It is not only because of the longer computational time, but mainly because of required soil properties and their uncertainties.

3. Numerical Model of The Approach Slab Experiment

Fig. 2 represents the numerical model in FEM software SOFiSTiK and it shows the arrangement of the experiment being in preparation. Dimensions of the soil tank are 3.9 m in width, 4.2 m in length and 2.25 m in height. Soil will be filled up to 2 m. The walls will be constructed by DOKA framed formwork system. Specimen of the approach slab will be in geometrical scale 1:2 with reduction of width. As a load pattern, one axle of the tandem system will be used. Reinforcement arrangement will be set to maintain the same reinforcement ratio as it is in approach slabs designed for real structure.

Analytical model consists of beam (1D) elements represented by the incline struts and frames of the formwork. 2D elements are used for laminated slabs of the formwork and the approach slab itself. Soil is represented by 3D tetrahedral elements. All elements are linear. Contact between the slab and 3D soil elements is represented by node to node springs, with soil properties.

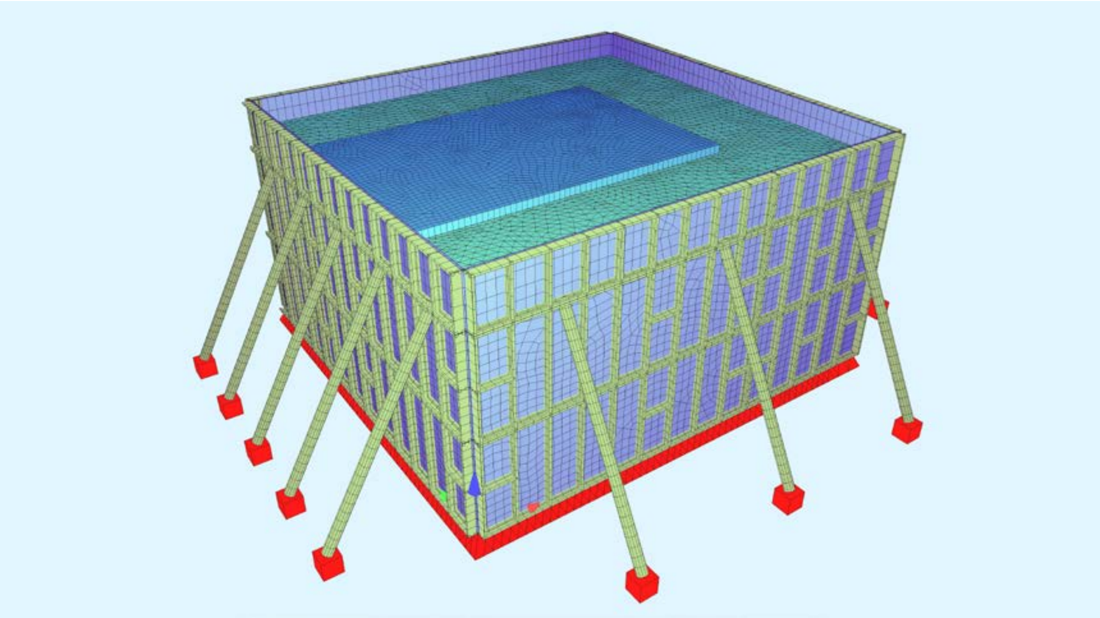

Fig. 2: Numerical model of the approach slab experiment

Material nonlinearities are fully included in all types of elements. In the concrete slab, estimated areas of the reinforcement were entered and 2D elements are later computed via layers dividing the height of the cross-section. Concrete properties and stress–strain curves were set as normative values according EC 2.

Hardening soil nonlinearity was chosen for the subsoil material, because of the type of soil elements. Due to its stress-strain curvature and possibility of changing the material properties in time, it is suitable for the nonlinear time-step analysis.

Reference load of the FEM analysis was 150 kN at each of two loaded areas, which should represent the contact pressure caused by wheels of the vehicles. Period of the sinus loading function was 0.35 s. The factor of the acting load was set as time variable of this function. The highest peak was 1.0, the lowest 0.1.For last two seconds of the loading function the factor was set to 0.

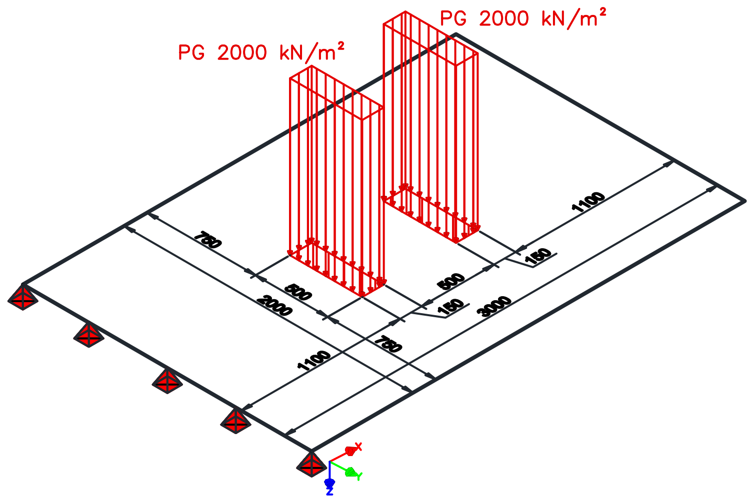

Fig. 3: Approach slab with applied load in the numerical model

The FEM analysis was focused on the behaviour of the slab and its interaction with subsoil. Soil pressure under the load areas was increasing in time, and after the end of cyclic loading, bedding stress goes to 0 MPa. Soil pressure development in time is shown in Fig. 4. With the consideration that the self-weight is acting during whole analysis, zero bedding stress suggest the creation of the void under the slab.

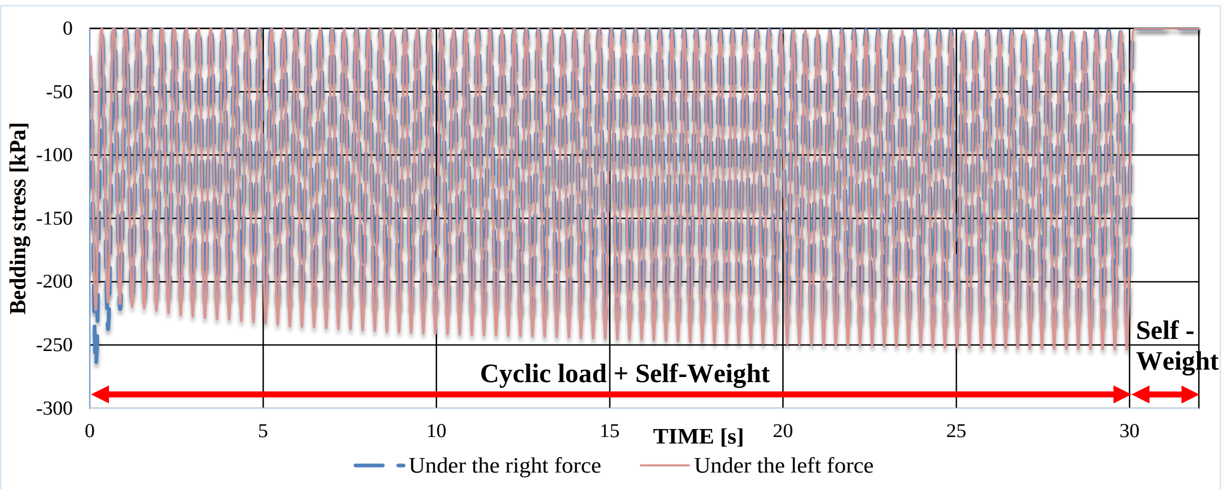

Fig. 4: Development of bedding stresses under applied loading areas in time

Another interesting behaviour was observed in support reaction of the assumed abutment. Because of the development of another theoretical soil support in front of the line support representing the abutment, reaction in all nodes of the line support are decreasing. Results prove the gap creation under the acting loads. It is necessary to mention, that the vehicle load is moving, and in real structure, the cyclic loading is not located only in the middle of the slab.

From the graph in Fig. 5 can be the changes of the structural scheme of the analysed slab assumed. On the horizontal axis, the position of the centre line along the span length of the slab is displayed. Vertical axis represents the deflections, and the time steps are described by depth axis. Deflection in the middle of the slab is decreasing in time and the free edge is rising. It can be presumed, that soil-hardening support on this edge is developing, what could explain all the observed behaviour of the slab from the performed analysis.

Further investigation in bigger time scale is advised as well as improving the meshing for better energy convergence and smaller numerical errors.

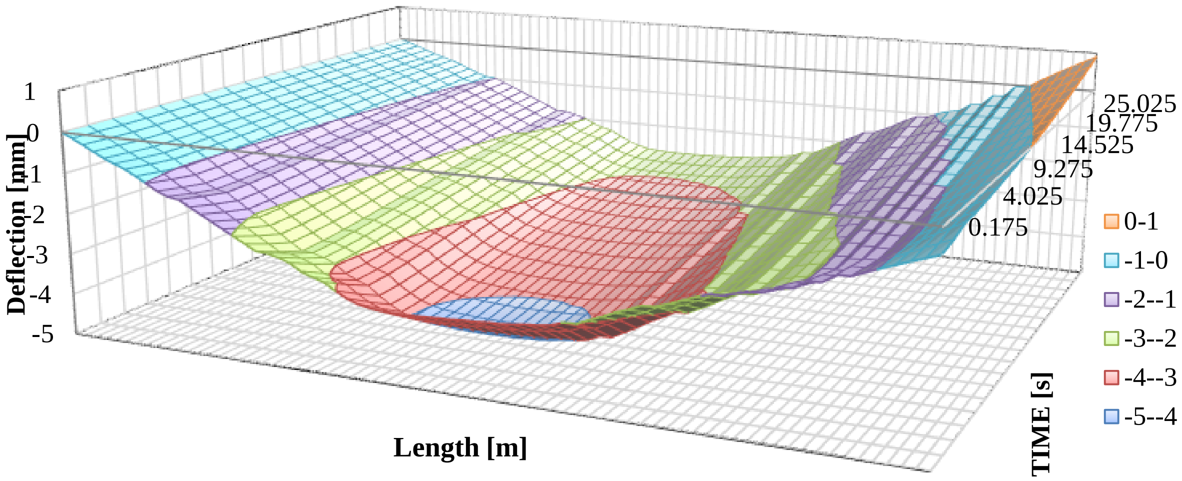

Fig. 5: Deflection development of the centre line of the analysed slab in time

4. Conclusion

In this work some problems concerning with estimation of the actual behaviour of the approach slabs were presented. Interaction of the slab structural member with the subsoil is complex problem and a discussed question among many researchers. When effect of a time and also a cyclic loading is added, even more questions are appearing.

After series of experiments, numerical model, as well as material properties will be carefully optimised according to the results. Main goal is to match the behaviour, deflection and reinforced concrete strain in highest possible accuracy. With right computational method and the material properties, 2D FEM model of the transition zone can be used for parametrical study. In this case, the possibility of using the moving cyclic load could be implemented.

Extended study could also use complete 3D FEM model, with consideration of wings of the abutment, or pile foundation and transverse strain of the elements. It is suggested to compare the results with in-situ measurements for the analysis verification.

Acknowledgement

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