The Subsidence Analysis of Post-tensioned Slab-on-Ground Secundary Reinforced by Polypropylene Fibres

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This experimental static load test is part of research activities scoped on problematics with involved foundation conditions. Especially for areas with influence of undermining or flood hazard. Concept of experiment was designed like a model situation of interaction between concrete column, concrete slab-on-ground and subsoil. During static load process were measured deformations, tensions inside the experimental model and geotechnical values on contact surface of concrete slab-on-ground and subsoil. These data were processed and used for creation of 3D FEM model.

Key-Words: Post-tensioned concrete, FEM analysis, Poplypropylene fibres reinforcement, Interaction between subsoil and slab-on-ground

1 Introduction

Interaction between concrete structure and subsoil is one of the main research direction at the Faculty of Civil Engineering, VSB – Technical university of Ostrava [1]-[3]. Actually, research is focused on experimental testing of different types of industrial floors. For experimental static load test was concreted model of plain concrete industrial floor.

The experimental model was designed as a part of plain concrete industrial floor without reinforcement and static load test was conceived as a simulation of loading by base plate of heavy rack. The experiment served to a better understanding and possible improvement of these technologies from the perspective of interaction with the subsoil.

2 Concept of Experimental Static Load Test

Experiment was designed like a model situation of interaction between concrete column, concrete slab-on-ground and subsoil.

Main part of experimental test was concrete slab model in large scale. This model had squere plane shape with the basic dimension 2,0 x 2,0 m and with slab thickness 0,15 m. The fresh concrete with class of concrete C25/30 XF1 was delivered by commercial supplier of concrete.

Six fully threaded prestressing threadbars were used for post-tensioning of experimental concrete slab model. The material of threadbars was from low relaxation steel with designation Y 1050 and diameters of these threadbars were 18 mm. The size of post-tensioning force for each threadbar was 100kN. Threadbars were prestressed with use of hydraulic hollow cylinder. Threadbars were anchored by domed nuts and recessed anchor plates. The experimental slab was based on homogeneous sand subsoil and situated in outdoor testing device STAND [4]. The vertical load was caused by the high tonnage hydraulic cylinder.

The loaded equipment was placed between the experimental model and the steel extension fixed on the testing device for experimental measurements of foundation slabs on the subsoil "STAND"

The hydraulic system was equipped with the pressure sensor. The vertical load was caused by the high tonnage hydraulic cylinder ENERPAC CLRG.

The loaded equipment was placed between the experimental model and the steel extension fixed on STAND. The hydraulic system was equipped with the pressure sensor. Potentiometric position sensors were installed on the surface of concrete floor model.

These gauges were connected to the same sensor station with automatic scanning and recording. Shape and size of load area simulated base plate of heavy loaded rack. Dimensions of load area were 400 x 400 mm.

Fixed interval of loading - 75kN / 20 min was chosen for this experimental testing. Vertical deformations were measured and recorded by the set of 16 potentiometers AHLBORN. FWA100T. Potentiometers were connected with the sensor station ALMEMO 5590. The station was programmed to automatic scanning and recording measured values. Schematic plan of sensors are displayed on Figure 2.

3 Measurement and Testing Devices

Measurement and testing devices are displayed on Fig. 1. and Fig 2.

1) Main high tonnage hydraulic cylinde

2) Recording station for potentiometric sensors

3) 4 strain gauges for measurement inside the experimental slab – tension of concrete

4) Hydrostatic leveling gage

5) 4 strain gauges for measurement inside the experimental slab – tension of concrete.

6) Central PC

7) 3 geotechnical pressure cells for measurement of the stress on the interface of the slab and subsoil.

Fig.1 Measurement and testing devices

Fig.2 Positions of geotechnical pressure cells

4 Subsoil characteristics

· Subsoil consists of loess loam with F4 consistency.

· Thickness of subsoil layer is about 5 meters.

· Volumetric weight of soil γ = 18,5 kN.m-3.

· Poisson coefficient ν = 0,35.

· Static Young's modulus EDEF = 10 MPa.

5 Results of vertical deformation measurement

Vertical deformations were measured by the set of 16 potentiometers. Potentiometers were connected to the recording sensor station. The station was programmed to automatic scanning and recording measured values. Time interval for record of deformation measurement was 10 seconds. Schematic plan of sensors is displayed on Fig. 3. Subsidence of experimental post-tensioned slab-on-ground model in line A-A´ is displayed on Fig.4. Subsidence of experimental post-tensioned slab-on-ground model in line B-B´ is displayed on Fig.5.

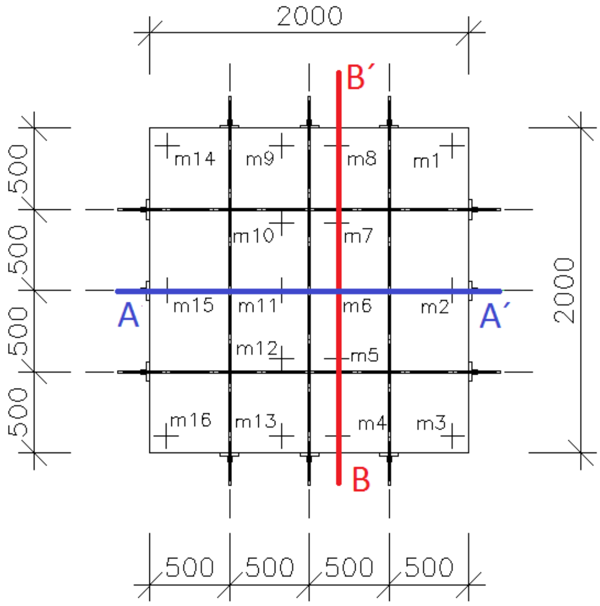

Fig.3 Schematic plan of potentiometers

Subsidence of experimental post-tensioned slab-on-ground model in line A-A´ is displayed on Fig.4. Subsidence of experimental post-tensioned slab-on-ground model in line B-B´ is displayed on Fig.5.

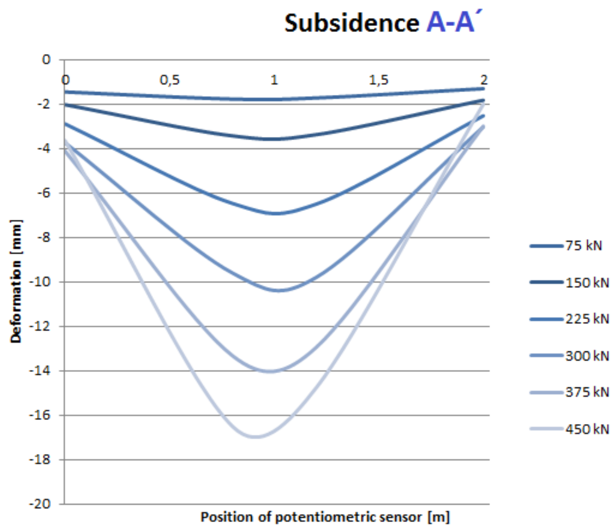

Fig.4 Subsidence line A-A´

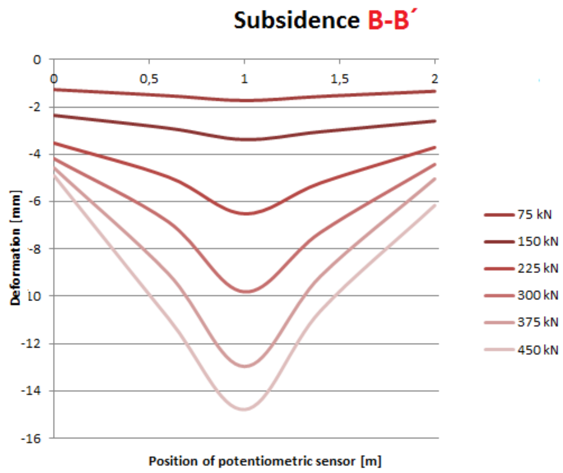

Fig.4 Subsidence line B-B´

5 3D Numerical Model

The interaction between subsoil and foundation slab was solved using numerical modeling and simulation with ANSYS 18.0 software. The data for the example were taken from the measurements of experimental model during the load test.

5.1 Description of the Numerical Model

The concrete slab was modelled as three-dimensional structure using brick element SOLID 65. The slab elements contained smeared reinforcement which represents the polymer fibers in the concrete. The subsoil was modeled with a three-dimensional 20-node brick element SOLID 186. The subsoil is represented by a hemisphere of a radius of 2 meters with coarse mesh. Instead of classical boundary conditions semi-infinite elements were used. The elements are derived from the edge elements of the hemisphere using mapping functions that project external face and nodes into infinity. All displacements of these external nodes are set to zero. The element edge length for the subsoil is 80 mm. The area of plate was meshed using elements with size 0.05 x 0.05 x 0.038m.

Homogeneous half-space was used for the analysis of the interaction between loaded slab and subsoil..
The contact area between the concrete slab and the subsoil can transfer only compressive forces and the transfer of the compressive forces depends on whether the two surfaces are in contact or not. The solution is an iterative process and the calculation automatically includes changing-status nonlinearity. The contact is realized using surface to surface contact element pair TARGE170 – CONTA174. The friction between the concrete slab and the

subsoil in contact area is neglected. The self-weight of the subsoil and the floor slab are considered in calculation.

Vertical load, which was generated by a hydraulic press, was distributed by steel plate of dimensions 0.4 x 0.4 x 0.05m. The steel plate was modelled using 4-node element SHELL 181.

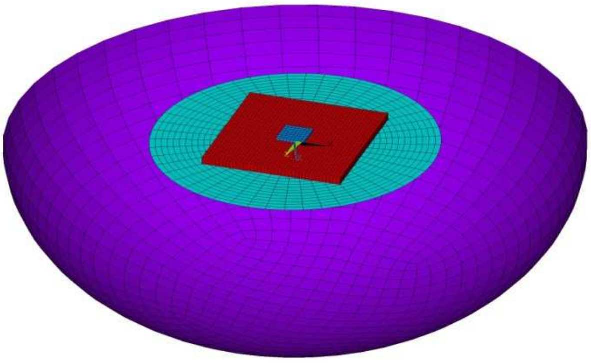

Fig.5 Model of slab resting on the subsoil. Purple semi-infinite elements, cyan solid subsoil elements, red solid plate elements, blue steel plate shell elements.

5.2 Stress and deformation Results

The size of modeled area of the subsoil and boundary conditions significantly affect resulting deformations in three-dimensional numerical simulations. Semi-infinite elements were used to reduce this affect.
Fig. 6 shows total vertical displacement of the subsoil model. As assumed, the maximum subsidence is located in the middle of the slab and its value is 19.23mm. The deformed shape of the model is symmetrical, which indicates that the symmetrical load and boundary condition were applied.

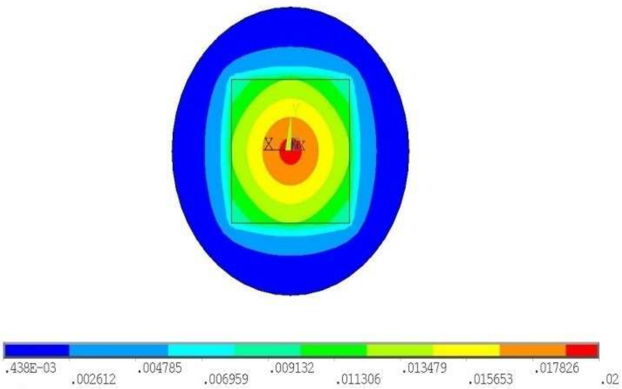

Fig.6 Total vertical displacement of the subsoil model [m]

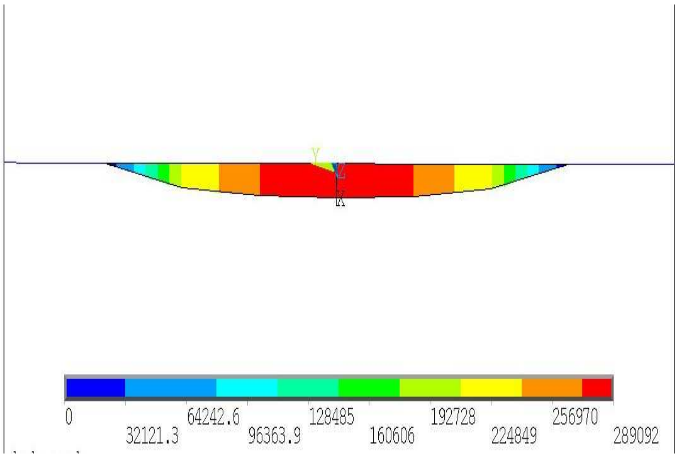

Fig.7 Contact pressure in transverse cross-section

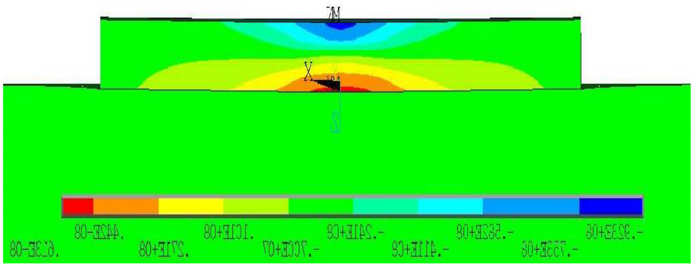

Fig.8 Normal stress sx in the transverse cross-section

6 Summary

Experimental prestressed concrete industrial floor model resist the loads exerted after seven load cycles and induced maximal load level 525 kN. First significant cracks were detected after fourth cyclus. These cracks were located near anchors of middle threadbars. After sitxth cyclus were detected first signs of punching share.

Experiment was ended in moment, when the model was strongly damaged by punching share. These experiment bring many informations about influence of prestressing to punching share restistance. Measured data will serve for creating of numerical model by FEM (finite element methode). [5, 6, 7, 8].

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References:

[1] P. Mynarcik, The Subsidence Analysis of Experimental Post-tensioned Concrete Slab Model in the Course of the Static Load Test, *Applied Mechanics and Materials*, vol. 744 – 746, pp. 1556-1559 (4 p), Trans Tech Publications, Switzerland, doi:10.4028/www.scientific.net/AMM. 744 – 746.1556, 2015.

[2] P. Mynarcik, Measurement processes and destructive testing of fibre concrete foundation slab pattern, *Advanced Material Research*, vol. 1020, pp. 221-226 (6 p), Trans Tech Publications, Switzerland, ISSN (Online) 1662-8985, ISSN (Print) 1022-6680, DOI: 10.4028/www.scientific.net/AMR.1020.221, 2014.

[3] R. Cajka, R. Fojtik, Development of Temperature and Stress during Foundation Slab Concreting of National Supercomputer Centre IT4*, Procedia Engineering,* vol. 65, 2013, pp. 230-235 (6 p), ISSN 1877-7058, doi: 10.1016/j.proeng.2013.09.035.

[4] R. Cajka, V. Krivy, D. Sekanina, Design and Development of a Testing Device for Experimental Measurements of Foundation Slabs on the Subsoil, *Transactions of the VŠB – Technical University of Ostrava*, Civil Engineering Series, vol. XI, iss. 1, pp. 1-6 (6 p), ISSN (Online)1804-4824, ISBN 978-80-248-2332-4, doi: 10.2478/v10160-011-0002-2, 2011.

[5] M. Janulikova, M. Stara, Multi-layer Rheological Sliding Joint in the Foundation Structures, *Transactions of the VŠB – Technical University of Ostrava,* Civil Engineering Series, vol. XIII, iss. 2, pp. 41–46 (6 p), ISSN (Online) 1804-4824, ISSN (Print) 1213-1962, doi: 10.2478/tvsb-2013-0008, 2013.

[6] R. Cajka, Analytical derivation of friction parameters for FEM calculation of the state of stress in foundation structures on undermined territories, *Acta Montanistica Slovaca*, vol. 18, iss. 4, pp. 254-261 (8 p), ISSN: 13351788, 2013.

[7] J. Labudkova, R. Cajka, Comparsion of Measured Displacement of the Plate in Interaction with the Subsoil and the Results of 3D Numerical Model, *Advanced Material Research,* vol. 1020, pp. 204-209 (6 p), Trans Tech Publications, Switzerland, ISSN (Online) 1662-8985, ISSN (Print) 1022-6680, DOI: 10.4028/www.scientific.net/AMR.1020.204, 2014.

[8] R. Cajka, K. Burkovic, V. Buchta, R. Fojtik, Experimental soil - Concrete plate interaction test and numerical models, *Key Engineering Materials*, vol. 577-578, pp. 33-36 (4 p), Trans Tech Publications, Switzerland, doi:10.4028/www.scientific.net/KEM.577-578.33, 2014.