Gliwice, 02.12.2020 r.

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Subject of doctoral dissertation:	System analysis: pile – subgrade loaded with horizontal force taking into account the change in rigidity of the system.
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Summary in English

Analysis of the work of the pile under horizontal load is complex due to the requirement to take into account the nonlinear behavior of both the soil and the pile. It requires defining the characteristics of both elements.

The aim of the work was to assess the pile bending behavior with a circular cross section reinforced with a steel profile taking into account the change in its stiffness and nonlinear change in ground depth and resistance. The basis for assessing the work of the system: pile – subgrade were the results of laboratory tests, which were subsequently used to calibrate and verify the proposed numerical models.

The analyses were conducted in two ways using different methods of modelling the stiffness of the pile depending on its diameter. Firstly, a field load test was carried out for two piles with a diameter of 0,4 m measuring the displacement of the pile head and the deformation of the steel profile by means of displacement sensors and strain gauge, respectively. Since only the results of the displacements of the pile head were available, laboratory tests were carried out on the pile itself (without surrounding subgrade) operating in a cantilevered scheme and exposed to a concentrated force perpendicular to its axis. Based on the results of laboratory tests, an analysis of the shape of the deflection line was carried out together with an assessment of the degradation of the stiffness of the element as a function of the bending moment (function $B(M)$ is chosen). In addition, the ability to determine the load capacity of a pile (reinforced with a steel profile) for bending according to the procedures used in the design of typical reinforced concrete (combined) elements.

Secondly, two piles with a diameter of 0,5 m were tested in the field. During the tests displacements along the length of the pile were measured by inclinometer. These tests allowed numerical models to be calibrated without the need for laboratory tests on pile bending. For piles with a diameter of 0,5 m, the function that conditions the flexural stiffness on the bending moment $B(M)$ was determined by a semi-reverse method.

The tests and analyses carried out and supplemented by tests on the strength and deformation parameters of the subgrade and concrete materials allowed for the calibration of numerical models. In behavior simulations of pile bending the finite

element method (FEM – 3D model) and the finite difference method (FDM – pile model) were used. Analyses by means of finite element method were based on constitutional models implemented in the program. Elastic and elastic-plastic models were used. In the bar model calculations were made with constant rigidity along the length of the pile and the designated function $B(M)$ for a pile with a diameter of 0,4 m was implemented while for a pile with a diameter of 0,5 m a function determined by the semi-reverse method was used. Verification of models for piles with a diameter of 0,4 m and 0,5 m was made by comparing the results of displacements measured in the field with the calculated results.

The dissertation is concluded with conclusions, the most important of which are:

1) The assessment of stiffness of both the pile and the subgrade is relevant and affects the values of bending moments and displacement of the pile head.
2) The common assumption of linear behavior of the pile during bending is incorrect. Adopting a constant pile stiffness for bending an equal initial value (not an outlined element) leads to an underestimation of pile displacements.
3) Predicted bending moments including nonlinear behavior are less than those obtained from the analysis which takes into account the linear behavior of the pile.
4) Taking into account the nonlinear behavior of the pile, a change in the resistance distribution of the subgrade along the length of the pile is observable.

A proposal for further research is also submitted.