SHEAR SKIN TRANSFER OF CONCRETE BORED PILES TESTING AND MODELING

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1. Introduction

Owing to a rapid development of infrastructure near the town Chomutov, the north part of Czech republic, the railway is currently under construction. Individual piers of bridges are founded on pile foundations. In this regard, several in situ tests were realized. In our contribution we are focused on investigation of pile behavior. As an example we consider bored concrete pile 1.22 (m) in diameter and 18.5 (m) long.

Resulting experimental data were obtained by measuring vertical strains at various depths in the instrumented pile during the tests. From measured strains and known moduli of deformation the normal force diagram in the pile was completed. For various pile head loads the normal force diagram in the pile as a function of depth were obtained and consequently the measurement was compare with calculation.

A semi analytical procedure was carried out to compute a settlement and normal force distribution of the axially loaded concrete bored pile. The deformation variant of the solution was selected. The pile-soil interface is modeled using physical nonlinear soil springs. The shear peak forces are limited. The value of the force depends on the vertical earth pressure and on the quality of the soil pile interface in the investigated point. For the shear response of the soil layer the known analytical solution is adopted.

2. Method of analysis

The solution is located in a layered soil. The pile is discretized into a finite number of cylindrical bar elements. The soil-pile interface is concentrated to the nodal points. The ultimate shear force in the node is obtained from the formula

$$T_{k,\lim} = 2\pi r_k l_k \tau_{k,\lim} \quad ,$$

where r_k is the radius of the pile in the *k* node,

l_k is the length of the shear influence around the *k* node,

$\tau_{k,\lim}$ is the ultimate shear strength and is proportional to the normal earth pressure in the soil-pile interface. Visualization of this dependence is shown in the fig. 1.

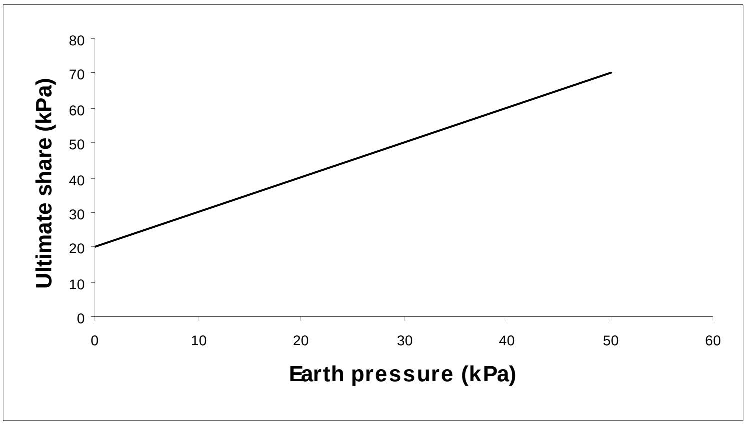

Figure 1: Example of ultimate shear calculation

The influence of the shear zone around the *k* pile node is assumed to be representing by spring [1]. The spring stiffness is calculated from the known analytical formula [2]

$$k_k = 2\pi r_k \sqrt{C_{1k} C_{2k}} \frac{K_1\left(\sqrt{\frac{C_{1k}}{C_{2k}}} r_k\right)}{K_0\left(\sqrt{\frac{C_{1k}}{C_{2k}}} r_k\right)} \quad ,$$

where r_k is the current radius of the pile,

C_{1k} , C_{2k} are current Winkler-Pasternak parameters of the soil around the *k* pile node,

K_0 , K_1 are the modified Bessel functions.

The stiffness in the bottom of the pile spring is reached by adding

$$k_b = \pi r_b^2 C_{1b} \ ,$$

r_b is the pile bottom radius,

C_{1b} is Winkler-Pasternak parameter in the pile bottom region. Presented ideas were incorporated in the consequently used numerical procedure [3].

3. In situ measurement

The arrangement of the in situ investigation of the piles was introduced. Several measurements in the various geological conditions were realized. Several remarks could be proposed from the observation of the axial force distribution and of the observation of the pile head settlement. The shape of axial force distribution attains a similar shape. So this information seems to be rather deficient. It is necessary to carry out several load cases for each single pile. Such a way gives us an opportunity to calculate the relative distribution of the axial force. The term relative means an axial force per 1 MN of the applied force. Relative axial force distribution describes more accurately behavior of the pile and its property. Anyway this information must be accompanied by some values of the settlement. To underline the remarks, some kinds of results are presented.

4. In situ measurement versus calculation

To compare numerical and experimental data we calculated the axial force in the pile and the head pile settlement. The soil parameters were adopted using the Czech standard in correlation to geological profiles classification.

The layer profile was consists of three layers. The first layer covers the clay up to depth of 11,5 m. The second layer contains widely weathered clay stone reaches up to depth of 14,5 m. The last layer with weathered clay stone with coal inclusions late reaches up to depth of 18,5 m. Material properties of individual layers and properties of the pile-soil interface are listed in Table 1.

Table 1

	E (MPa)	ν	Cohesion (kN/m^2)	Friction angle	γ (kN/m^3)
Layer 1	10	0.4	30	10°	21
Layer 2	16	0.4	5	19°	20
Layer 3	100	0.3	0	20°	20

Figure 2 shows the measurement and calculation of the pile settlement.

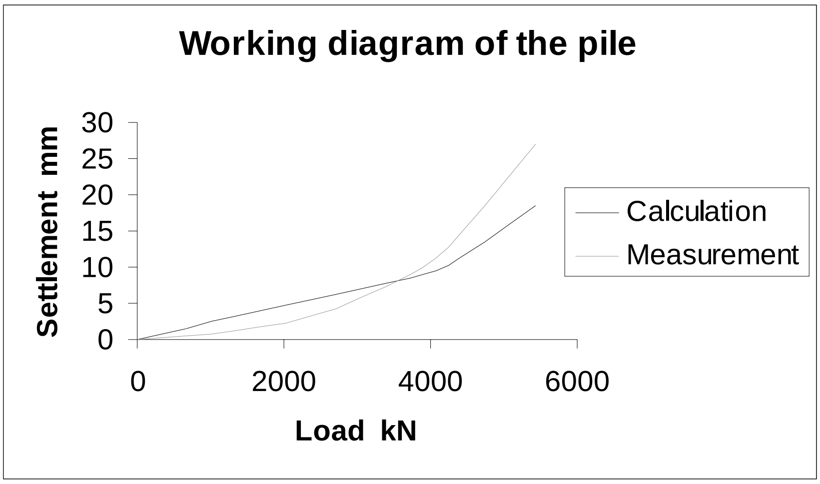

Figure 2: Working diagram of the bored pile, measurement and calculation

. The measured normal force results and calculation are presented in Fig. 3. Comparison underlines the capability of the mentioned numerical procedure.

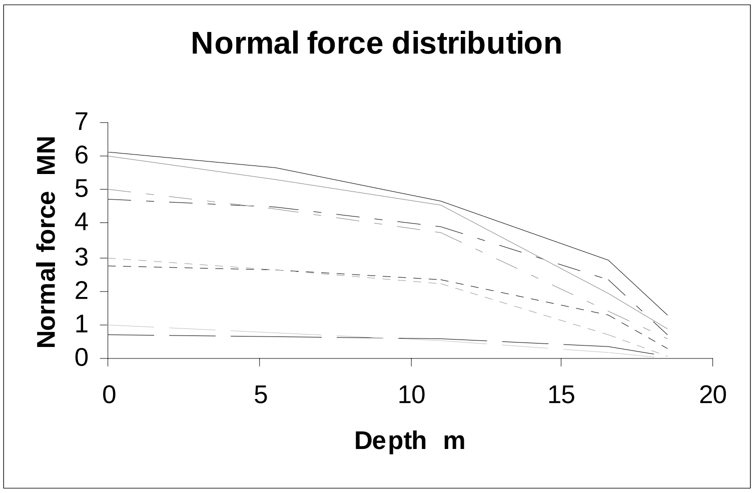

Figure 3: Normal force distribution, measurement (gray lines) and calculation (black lines)

Conclusion

Presented tests show fatal influence of the shear skin transfer on the pile behavior. In such a way all research activities must be focused on the investigation of the pile-soil interface and its improvement by the technology process. Only with good description of the pile-soil interface the prediction of the pile behavior will be successful.

References

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