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Differences in Determination of Bored Pile Compressive Resistance in Slovakia and Poland

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Abstract

The paper deals with differences in determination of bored pile compressive resistance in Slovakia and Poland. Common procedures of determination of bored pile compressive resistance, applied in Slovakia and Poland, will be introduced. It will be shown in examples that various calculation procedures take into account various factors influencing pile compressive resistance in different way, therefore pile compressive resistances determined by various procedures will be different. It will be also shown, that underground water has strong impact on pile compressive resistances so reliable determination of its presence and its change during pile life can contribute to economic pile design.

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Keywords: bored pile; pile compressive resistance; pile base resistance; pile shaft resistance; density index; consistency index.

1. Introduction

Pile design is quite complicated from the reasons that piles are embed in various soil and there are many technologies, which influence base resistance and shaft resistance. It is hard to evaluate mentioned influence and various design approaches introduce various coefficients to take into account mentioned influences. In Slovakia, at the present, the Slovak Technical Standard STN 73 1002 applied from 01.04.1989 is still valid. However, in the Standard, there are only tabled values of pile compressive resistance posted, no formula for calculation of base resistance and shaft resistance is introduced. Therefore in practice, the procedure introduced in [1] is more often

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applied. By the procedure, a base resistance and shaft resistance will be calculated, taking into account various influence on them. In Poland, at the present, no specific Polish Standard for pile design is valid. Since applying Standards is not obligatory in Poland, even the PN-83/B-2482 [2] is withdrawn; it still often applied in Poland. Not as valid STN 73 1002, there are no tabled values of pile compressive resistance posted but base resistance and shaft resistance are introduced for various kinds of soils. From the reason that Eurocode 7, part I [3] does not introduce any specific procedure for calculation of pile compressive resistance, a comparison of procedures of calculation of pile compressive resistance bored in soil in Slovakia by [1] and in Poland by [2] will be useful.

2. Determination of pile compressive resistance in Slovakia

By [1], pile compressive resistance will be calculated using a formula:

$$U_{vd} = U_{bd} + U_{fd} \tag{1}$$

where U_{vd} is design pile compressive resistance (kN); U_{bd} is design pile base resistance (kN) and U_{fd} is design pile shaft resistance (kN). The design pile base resistance U_{bd} can be calculated using a formula:

$$U_{bd} = K_1.A_b.R_{db} \tag{2}$$

where K_1 is a coefficient for foundation depth, taking into account pile length L. The minimum value $K_1 = 1.0$ is applied for $L \leq 2.0$m and the maximum value $K_1 = 1.15$ is applied for $L > 6.0$m. A_b is a pile base area (m^2) and R_{db} is a bearing capacity of soil under pile base (kPa), which can be calculated using a formula:

$$R_{db} = 1.2c_d.N_c + (1 + sin\varphi_d).\gamma_1.d.N_d + 0.7\gamma_2.(b/2).N_b \tag{3}$$

where d is a depth of pile base under terrain (m); b is a pile diameter (m); meaning of other symbol are the same as in the Slovak Technical Standard STN 731001 [4] with exceptions in calculation of soil design angle of internal friction φ_d and design cohesion c_d:

$$\varphi_d = \varphi/\gamma_{m\varphi}\ ;\ \gamma_{m\varphi} = 1.4$$
$$c_d = c/\gamma_{mc}\ ;\ \gamma_{mc} = 2.0$$

The design pile shaft resistance U_{fd} can be calculated using a formula:

$$U_{fd} = u.\sum h_i.R_{dfi} \tag{4}$$

where u is a pile perimeter (m); h_i is a thickness of the layer i, in which the shaft resistance is calculated (m) and R_{dfi} is a design friction on pile shaft in layer i (kPa), which can be calculated using a formula:

$$R_{dfi} = K_2.\sigma_{ori}.tg(\varphi_d/\gamma_{r1}) + c_d/\gamma_{r2} \tag{5}$$

where σ_{ori} is a origin effective geostatic stress in a depth z_i under pile head; K_2 is a coefficient of horizontal soil pressure on the pile and equals 1.0 if $z_i \leq 10$m and equals 1.2 if $z_i > 10$m.

γ_{r1} is a coefficient taking into account technology of pile performance. The minimum value $\gamma_{r1} = 1$ is applied for pile concreting without casing and the maximum value $\gamma_{r1} = 1.6$ is applied for concreting using suspension and PVC or PE or concreting of borehole diameter larger than 2m using suspension.

γ_{r2} is a coefficient taking into account a depth z_i under pile head. The minimum value $\gamma_{r2} = 1$ is applied for $z > 3$m and the maximum value $\gamma_{r2} = 1.3$ is applied $z_i \leq 1$m.

When calculating pile shaft resistance U_{fd}, a friction shall not applied for a length L_p from pile base. The value of L_p can be calculated using a formula:

$$L_p = 0.25b.N_d^{0.67} \tag{6}$$

3. Determination of pile compressive resistance in Poland

By [2], pile compressive resistance can be calculated using a formula: