The negative skin friction of bearing piles

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The Negative Skin Friction of Bearing Piles

THESIS

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c) τ_{p-s_m} can be estimated with a laboratory test as already mentioned in Chapter 6, or obtained as shown in Chapter 7.

b) Concerning the pile

The diameter or side length, as well as the shoe form and dimensions, so as to permit the calculation of U.

c) Consolidation pressure

The consolidation pressure p_c, as well as the area concerning the pile or pile-group.

d) Moreover, it is preferable to know the shear strength and the cohesion as given by the triaxial apparatus and the sensitivity of the soil.

CHAPTER 9

Summary and Zusammenfassung

A. Summary and conclusions

1. The effect of drag forces on piles produced by the settlement of adjacent soil has been widely recognised in a qualitative manner for some time. Precise quantitative information has been lacking, as a result of which cases of failure have occurred or difficult and costly remedies have had to be executed. In order to provide practical information about these forces on bearing piles a laboratory study was carried out on a special model; a typical kind of loose soil (silty sand with clay) was used with various soil properties and under varying consolidation pressures.

2. The results are found to depend on the effect of two main sets of factors, as follows:

a) The first one concerns:

The consolidation pressure (p_c),

The pile diameter (U), and

The thickness of the compressibile layer (H) through which the pile penetrates to stand on a bearing strata.

b) The second set includes the soil properties, which are:

The ratio between the soil weight per horizontal unit area and the consolidation pressure ($\gamma_d H/p_c$), which is denoted by (λ),

The natural water-content (W_a %),

The dry volume-weight (γ_d) and

The porosity expressed by the specific gravity (γ_s) and the dry volume-weight (γ_d).

3. The greatest measured value of the drag force F_n is found to be proportional to the various parameters for the soil used as follows:

a) With repect to the consolidation pressure p_c:

$$F_n = \alpha_{p_c} + \beta_{p_c} p_c$$

where α_{p_c} is the negative skin friction force due to the complete consolidation of the soil under its own weight only, i. e. $p_c = 0$.

b) With respect to H:

$$F_n = \beta'_H (H - \alpha_H)$$

where α_H is found to be about 5 times the height of the pile-shoe, at the value of which the drag force ceased to appear.

c) With respect to γ_d:

$$F_n = \alpha_{\gamma_d} - \beta_{\gamma_d} \gamma_d$$

which states the inverse proportionality between F_n and γ_d.

d) With respect to W_a %:

$$F_n = \beta_W (W_a\,\% - \alpha_W)$$

where α_W gives the minimum natural water-content (about 1.2 times the optimum), below which no F_n occurs.

4. The maximum drag force F_n which hangs on a bearing pile can be computed from the following equation:

$$F_n = F_{n-s} + \kappa \left(a\, p_c H\, U - b\, \lambda^c \frac{W_a\,\%\, p_c^3}{\gamma_s \gamma_d} \right),$$

where the constants are:

$$\kappa = 0.416, \qquad a = 2.0$$
$$b = 0.70 \quad \text{and} \quad c = 2.0$$

and F_{n-s} can be calculated by the use of one of the methods given in Chapter 6. In the above-mentioned formula both H and W_a % are greater than zero.

5. To obtain the final form of F_n, referred to in section 4, the problem is treated by dimensional analysis and the π-Theory.

6. The results of the experiments led to an explanation of the phenomena of soil heave during pile penetrations.

7. It is found that a cylindrical zone round the pile shaft of a thickness of about half the pile diameter is completely remolded, on which surface the maximum stress producing maximum strains in the soil takes place. Further,

that another outer cylinder of thickness $1^1/_2$ times the pile diameter is sufficiently affected by the pile movement to result in a large increase in compressibility of the soil.

8. The results show that the end volume weights increase when we move inwards towards the pile shaft, and also with increasing depth from the soil surface under the same consolidation pressure. In addition, the rate of increase decreases as the consolidation pressure increases.

9. As an application, a practical problem was solved using the obtained formula and, for comparison, it was also solved by the method mentioned in section 1.2.2.

B. Zusammenfassung

1. Seit einigen Jahren ist der Einfluss der negativen Mantelreibung auf den Pfählen infolge der Zusammensetzung des anliegenden Bodens qualitativ bekannt geworden. Um solche Probleme vollständig zu behandeln, benötigt man bestimmte quantitative Informationen, die aber bis jetzt fehlen. Dadurch traten in vielen Fällen Misserfolge ein, oder es mussten schwierige und kostspielige Instandstellungsarbeiten durchgeführt werden.

Die Resultate der vorliegenden Arbeit ergeben sich aus den Versuchen an einem Spezialmodell eines stehenden Pfahles und einer geeigneten Labormethode. Dabei wurde eine typische Bodenart (siltiger Sand mit Ton) verwendet, jedoch unter verschiedenen Zuständen und veränderlichem Konsolidationsdruck.

2. In der wissenschaftlichen Untersuchung dieses Problems wurde die negative Mantelreibung (im weiteren mit „Dragkraft F_n" bezeichnet) in Abhängigkeit von den folgenden Hauptfaktorengruppen betrachtet:

a) Die erste Gruppe besteht aus dem:
   Konsolidationsdruck (p_c),
   Pfahlumfang (U), sowohl
   Mächtigkeit (H) der zusammendruckbaren Schicht, durch die der Pfahl eindringt, um auf einer tragfähigen Schicht zu stehen.

b) Die zweite Gruppe enthält die Bodeneigenschaften, und zwar:
   Das Verhältnis zwischen dem Bodengewicht pro horizontale Flächeneinheit und dem Konsolidationsdruck, ($\gamma_d H/p_c$), welches mit (λ) bezeichnet ist.
   Anlieferungswassergehalt (W_a %),
   Trockenraumgewicht (γ_d) und
   die Porosität, welche durch (γ_s) und (γ_d) ausgedrückt sei.

3. Man hat festgestellt, dass die Proportionalität zwischen der grössten gemessenen „Dragkraft (F_n)" und den verschiedenen Parametern, für die verwendete Bodenart, lautet: