III - A222

Influence of Some Parameters on the Location of Neutral Point for Floating Columns

M. Alamgir MJSCE, Saga University & BIT, Khulna, Bangladesh
N. Miura MJSCE, Saga University, 1 Honjo, Saga 840, Japan

1 INTRODUCTION

Location of the neutral point has an important role on the response of column-reinforced ground for its involvement in the balances of forces acting on the column. The parameters involved in the design of composite ground such as load intensity, column spacing, penetration depth and friction angle between column and soil, influence the location of neutral point. This paper describes further research works in this direction based on the authors previous work in which the downdrag problem is treated basically as a settlement problem. Results are presented to predict the location of neutral point varying the magnitudes of the parameters. Finite element method is also employed here to compare the predicted result for a typical example of column-reinforced composite soft ground and a reasonable agreement is obtained.

2 METHOD OF ANALYSIS

The problem of group floating columns installed into a homogeneous soft ground subjected to uniform surface loading over the entire area and undergoing consolidation settlement is shown in Fig.1. Since the column is stiffer than the surrounding soil, and as the consolidation of the clay layer proceeds, the surrounding soil moves faster than the column, the downdrag forces develop along the surface of column. The column-soil interface shear stress changes its direction from downward to upward at a point, known as neutral point, based on the magnitudes of the associated parameters and the consideration of no slip and slip conditions. The interface shear stress (Eq.2) is obtained from the vertical displacement component of the ground for no slip, $\tau(z)$, and from τ_f for slip conditions, by solving the integro-differential equation (Eq.1) expressing the settlement response of the composite ground (Poorooshasb et al. 1996).

$$\frac{\partial w(r,z)}{\partial z}+\frac{1}{E_s(z)}\int_0^z G(z)\left[\frac{\partial^2 w(r,z)}{\partial r^2}+\frac{1}{r}\frac{\partial w(r,z)}{\partial r}\right]dz=\frac{p_0}{E_s(z)} \quad (1)$$

$$\tau(z)=G(a,z)\frac{\partial w(a,z)}{\partial r}\,;\ \tau_f=K_0(\gamma' z+p_0)\tan\delta;\ \delta=0.5\phi \text{ to } \phi \quad (2)$$

where the symbols bear their usual meanings. The idealization of the foundation system, the boundary conditions for no slip and slip conditions and the finite difference numerical scheme adopted for solution are demonstrated fully in the paper mentioned above.

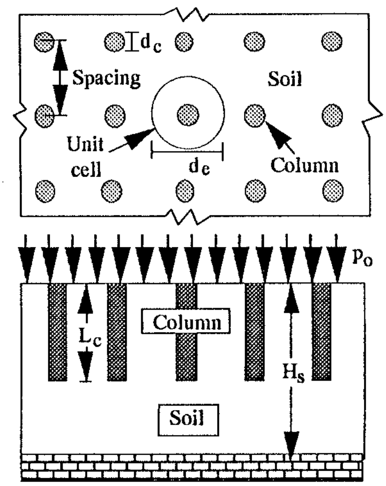

Fig.1 The problem to be analyzed.

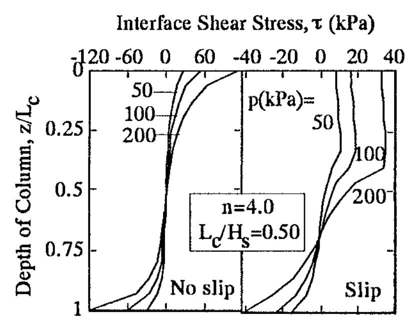

Fig.2 Influence of load intensity.

3 RESULTS AND DISCUSSIONS

Predictions are made for no slip and slip conditions to illustrate the influences of some parameters such as load intensity (p_o), column spacing ratio ($n=d_e/d_c$), degree of penetration (L_c/H_s) and friction angle between column and soil (δ) on the location of neutral point and thus presented in Figs.2-5. The values of the parameters are p_o=50 to 200kPa, L_c/H_s=0.25 to 0.75, $n=d_e/d_c$=3 to 5, E_s=1000kPa, E_c/E_s=25, γ'=8kN/m^3, ϕ'=20°, $\delta=0.70\phi'$and ν_s=0.40. Figure 2 indicates that as the applied stress increases the depth of neutral point is also increased. In calculating neutral point, the influence of p_o is found insignificant for no slip case compared with its slip counterpart. The spacing of columns, an important parameter for this type of foundation system, influences the location of neutral point significantly, as shown in Fig.3, which varies from 0.64 to 0.70L_c for increasing n values from 3 to 5, in case of slip analysis. Figure 4 illustrates the influence of degree of penetration, L_c/H_s, the parameter indicating the length of floating columns compared with the total depth of soil layer. For the increase of L_c/H_s from 0.25 to 0.75, the depth of neutral point increases significantly from 0.56 to $0.68L_c$ for no slip and 0.60 to $0.80L_c$ for slip analysis. The influence of friction angle (δ) is shown in Fig.5 varying its values from $0.5\phi'$ to ϕ'. As the value of δ increases, the depth of neutral point decreases. The higher value of δ provides higher allowable shear stress, prevents slip at interface, gives lower value of slip depth and thus reduces the depth of neutral point which in turn, reduces the length of column subjected to negative skin friction. The location of neutral point evaluating by this method is found to be in accordance with the findings of the other researchers, such as Wong and Teh (1995).

4 COMPARISON OF RESULTS

The result obtained from the present analysis for a typical example is compared here with finite element method using a standard program CRISP (Britto and Gunn 1987). The problem selected is that of a uniformly loaded soft ground improved by a group of floating columns having the values of p_o/E_s=0.10, d_e/d_c=4.0, L_c/d_c=5.0, L_c/H_s=0.50, E_c/E_s=25, ν_c=0.20 and ν_s=0.30. The details about the boundary conditions, finite element mesh and other considerations, are given in Alamgir (1996). Analyses are performed for no slip condition. The distribution of normalized interface shear stress, τ/p_o, along the depth of column, z/L_c, is shown in Fig.6. The present analysis underpredicts both the positive (i.e. acting downward) and negative (i.e. acting upward) shear stresses mobilized along the column-soil interface. But, it is interesting to note that the neutral point, the main concern in this study, is found almost at the same depth, which is around $0.6L_c$, for both the predictions.

5 CONCLUDING REMARKS

Based on the predicted results, this study can be concluded as: (i) The depth of neutral point is higher for slip analysis than that of for no slip counterpart, (ii) The depth of neutral point is influenced noticeably for changing the values of parameters such as load intensity, column spacing, penetration depth and friction angle at column-soil interface, and (iii) Comparison with FEM reveals that the present analysis can be used to determine the location of neutral point with a reasonable degree of accuracy.

ACKNOWLEDGEMENTS

The contribution of Prof. H.B. Poorooshasb, Concordia University, Montreal, Canada, and the support of Japan Society for the Promotion of Science (JSPS) by awarding Post Doctoral Fellowship to the first author are gratefully acknowledged.

REFERENCES

Alamgir M (1996). Analysis of soft ground reinforced by columnar inclusions. Ph.D. Thesis, Saga University, Japan.

Britto A M and Gunn M J (1987). Critical state soil mechanics via finite elements. Ellis Horwood Ltd.

Poorooshasb, H.B., Alamgir, M. and Miura, N. 1996. Negative skin friction on rigid and deformable piles. Computers and Geotechnics, 18(2):109-126.

Wong, K.S. and Teh, C.I. (1995). Negative skin friction on piles in layered soil deposits. Journal of Geotechnical Engineering, ASCE, 121(6):457-465.

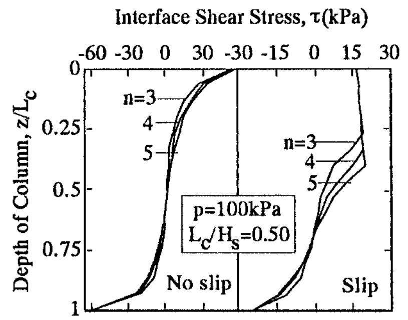

Fig.3 Influence of column spacing.

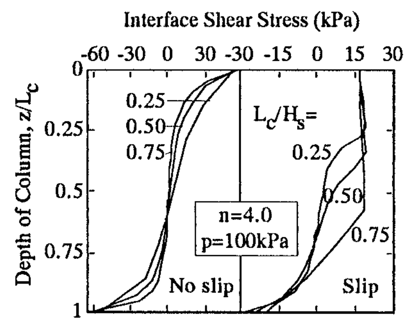

Fig.4 Effect of degree of penetration.

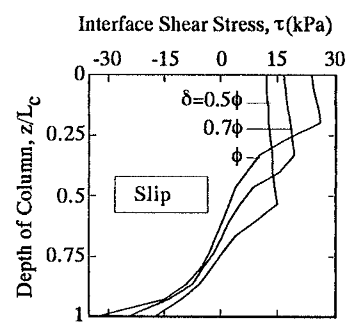

Fig.5 Influence of friction angle.

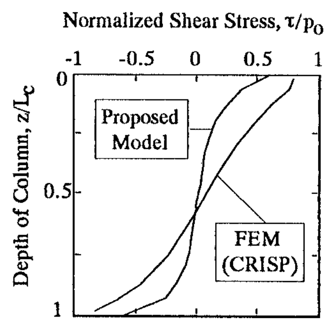

Fig.6 Comparison with FEM.