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Uplift Capacity of Anchor Plates in Two-layered Cohesive-frictional Soils

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Abstract: Based on a large number of laboratory model results many investigators reported the uplift loading of anchor plates embedded in homogeneous soils, a review of related last works shows that not much research has been done to define the ultimate uplift capacity in a two-layered cohesive-frictional soil, a problem that is often encountered in field. This study investigated experimentally the behavior of anchor plates buried and developed analytical expressions to estimate the uplift capacity of strip and circular anchor plates in layered soils. The study suggested an expression to determine the uplift loading of irregular shape anchor plates in layered cohesive soil. This research has developed experimentally expressions to estimate the uplift capacity of irregular shape anchor plates in layered cohesive-frictional soils. The study observed that the ultimate uplift capacity is dependent on the relative strength of the two layers, the depth ratio of embedment and the upper layer thickness ratio.

Key words: Anchor plates, cohesive-frictional soils, layered, uplift, irregular anchor plate, pullout

INTRODUCTION

During the past few years a great number of experimental model and numerical analysis results on the uplift resistance of anchor plate embedded in homo geneous cohesion less soil has been reported by many researchers. A review of related literature shows that not much research has been done to analyze the performance of anchor plates in layered soils a problem, which is often encountered by the professional engineers in the field.

Although some experiments, beginning from Stewart (1985) that studied the behavior of anchor plate embedded in a saturated clay layer overlain by a compacted sand deposit, the experimental consisted of laboratory model tests on circular anchor plate of 50 mm diameter and 5 mm thick as shown in Fig. 1. From this research it was found that the cohesion less soil overlay significantly increased the ultimate uplift capacity of the anchor plate compared with its value when embedded in clay alone that Fig. 2 shows them. The increase in uplift capacity is due to two main factors. The first is the additional over burden pressure, which converts the original shallow anchor plate into a deep anchor plate; the second is the mobilization of the frictional loading of the overlays. He showed that large displacements were needed to mobilize the frictional loading of the overlying cohesion less soil.

Sutherland (1988) pointed out that in practice little real benefit to uplift capacity could be a anchor plate embedded in cohesive soil since a large displacement is needed to mobilize the shear strength of the overlays. It was suggested that achieved by placing cohesion less soil over if a sand overburden were to be used, a more sensible solution would be to place the anchor plate on the surface of the cohesive soil layer and then place cohesion less soil on top.

Manjunath (1998) suggested a theory for define of vertical uplift capacity of a shallow horizontal strip anchor plate in two layered frictional - cohesive soil. The effect of surcharge has also been considered. The theory has been developed by using theory of characteristics coupled with log spiral failure surface having different foci for different layers shown in Fig. 3. Uplift capacity factors, separately for cohesion (F_c), surcharge (F_q) and unit weight (F_γ) have been presented as a function of embedment ratio, friction angle of each layer and ratio of top layer to the total embedment depth. Hence using these factors for the selection values of friction angle of bottom layer (φ_b), top

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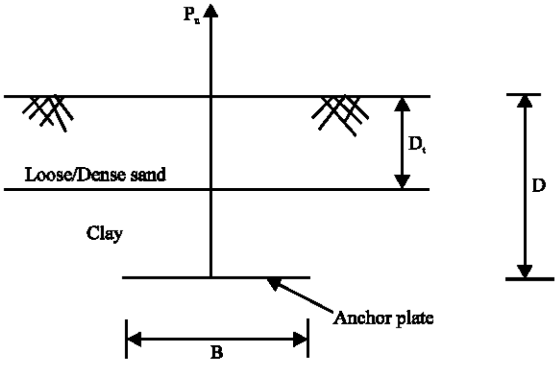

Fig. 1: Experimental investigations layered soil system used by Stewart (1985)

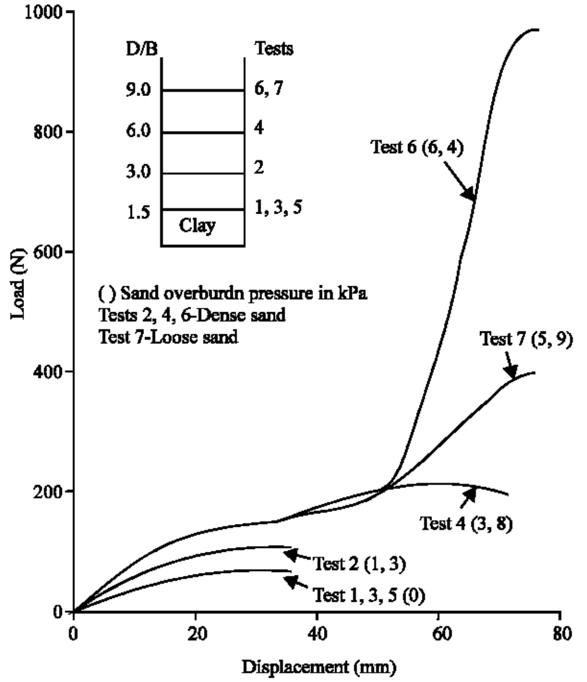

Fig. 2: Load-displacement curves of anchor plates in layered soil system by Stewart (1985)

layer (φ_t) and embedment ratio the vertical uplift capacity of shallow horizontal strip and circular anchor plates can be defined in two layered soils with surcharge for any value of D_f/D ratio. The net average ultimate uplift capacity (U ↓ (u- net) has been written in the form:

$$U_u\text{-net} = (d_t c_t + d_b c_b) F_c + qF_q + 0.5 (B d_r \gamma_r + d_b \gamma_b) F_\gamma$$

And the average ultimate uplift capacity (U_u) is as:

$$U_u = U_u\text{-net} + (D_r \gamma_r + D_b \gamma_b)$$

Niroumand and Kassim (2010a, b) reported the behavior of an irregular anchor plate buried in a two layered frictional-cohesive soils. The testing program consisted of two 159 and 297 mm long irregular anchor plates buried in soft clay overlain by loose sandy soil as shown in Fig. 4. The uplift tests were carried out on an irregular anchor plate embedded at a depth D in a combination of layers of clay-sand. The testing program consisted of an irregular anchor plates buried in soft clay overlain by loose sandy soil as shown in Fig. 5a, b. The thickness of each layer was increased to a certain proportion of the anchor long and it was increased from 1 to 4 and 1 to 7 times the long irregular anchor plates. It was reported that for upper layer thickness ratio of less

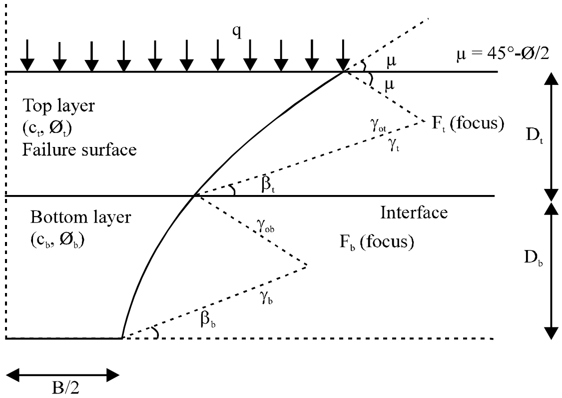

Fig. 3: Faliure mechanism in two layered soils by Manjunath (1998). where, γ_{ot}: Initial length of radial line of log-spiral failure surface in the top layer, γ_{ob}: Initial length of radial line of log-spiral failure surface in the bottom layer, γ_t: Final length of radial line of log-spiral failure surface in the top layer, γ_b: Final length of radial line of log-spiral failure surface in the bottom layer, β_t: angle between the final radial line () of log-spiral failure surface in the top layer and the horizontal at the interface

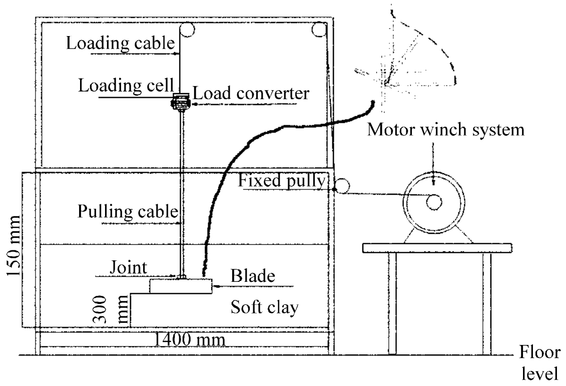

Fig. 4: Experimental investigations layered soil system used by Niroumand and Kassim (2010a, b)

Fig. 5: Testing setup used by Niroumand *et al.* (2010)

than one and for a given ratio, D/B there was no difference between the uplifting an anchor plate from a clay-loose sand bed. For a given D/B ratio and the upper layer embedment ratio of 1 to 4 a clay-loose sand bed in bigger irregular anchor plate gives a greater uplift than upper layer embedment ratio of 1 to 7 a clay-loose sand bed in smaller irregular anchor plate.

CONCLUSION

As a conclusion, this study shows that the last experimental works have been done regarding to performance of the anchor plate in layered frictional-cohesive soils. Inevitably such a wide range of parameters will contribute to conflicting conclusions for the ultimate uplift load of the anchor plates. These researches have been done, using different regular /irregular anchor plates and soil parameters. Unfortunately, the results obtained from the laboratory tests are typically a specific problem and are difficult to extend and develop to field problems, due to the different materials or the geometric parameters used in the field scale. It is observed that the ultimate uplifting capacity is dependent on the relative strength of the two layers, the depth of embedment ratio and the upper layer thickness ratio.

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