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Creep of Shallow Plate Anchor in Soft Clay

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ABSTRACT

Plate anchors are used on many occasions for various types of offshore construction and maintenance works. When the plates are embedded in a soft clay and are subjected to sustained allowable loads, they may undergo creep. This paper presents some laboratory model test results designed to study the creep effect with time for a shallow circular anchor subjected to sustained net loads that were less than the net ultimate uplift capacity. Based on the model test results, relationships between the net load, rate of strain, and time have been developed.

INTRODUCTION

In some situations plate anchors are used in various types of offshore construction and maintenance works. A number of laboratory and field test results are available in the literature to estimate the net short-term ultimate uplift capacity of plate anchors embedded in clayey soil (e.g., Ali, 1968; Kupferman, 1971; Adams and Hayes, 1967; Bhatnagar, 1969; Das, 1978, 1980; and Vesic, 1971). The results of most of these studies are summarized by Das (1990).

Fig. 1 shows a circular plate anchor of diameter D embedded in a soft saturated clay at a depth H. The *short-term* ultimate uplift capacity ($\phi = 0$ concept, where ϕ is the soil friction angle) of the anchor plate can be given by the relationship:

$$Q_u = Q_o + W_a + F_s \tag{1}$$

where Q_u = gross *short-term* ultimate uplift capacity, Q_o = net *short-term* ultimate uplift capacity, W_a = effective self-weight of the anchor, and F_s = mud suction force.

The mud suction force is primarily a function of the undrained cohesion and the coefficient of permeability of the clay. The *short-term* net ultimate uplift capacity, Q_o, can be expressed as (Vesic, 1971):

$$Q_o = A(\gamma H + F_c c_u) \tag{2}$$

where A = area of the anchor plate, γ = saturated unit weight, F_c = breakout factor, and c_u = undrained cohesion.

The breakout factor F_c is a function of c_u and the embedment ratio H/D. For a given clay, the breakout factor increases with the embedment ratio and reaches a maximum value (i.e., $F_c = F_c^*$) at $H/D = (H/D)_{cr}$. For $H/D \geq (H/D)_{cr}$, the magnitude of F_c ($= F_c^*$) remains constant. According to Das (1990):

$$F_c \approx n\left(\frac{H}{D}\right) \leq F_c^* = 9 \tag{3}$$

where n varies between 5.9 and 2 depending on the magnitude of the undrained cohesion, c_u. For circular anchors, the variation of the critical embedment ratio $(H/D)_{cr}$ can be given by an empirical equation (Das, 1978) as:

$$\left(\frac{H}{D}\right)_{cr} = 0.107c_u + 2.5 \leq 7 \tag{4}$$

where c_u is in kN/m^2.

Anchors with embedment ratios of $H/D \leq (H/D)_{cr}$ are referred to as *shallow anchors*. For shallow anchors, at ultimate load the failure surface in soil extends to the ground surface as shown in Fig. 2; however, for anchors with H/D greater than $(H/D)_{cr}$, the failure in soil takes place around the anchor and does not extend to the ground surface. These are referred to as *deep anchors*.

When a plate anchor embedded in soft saturated clay is subjected to a sustained net load $Q < Q_o$, the anchor is likely to exhibit some creep (upward movement with time). The creep rate will be a function of Q/Q_o, c_u, H/D, and also the type and amount of clay minerals present in the soil. This is an important factor in the design of anchors in many offshore projects. At the present time, published literature related to the evaluation of the creep rate of plate anchors embedded in soft clay is relatively scarce. The present paper provides the results of a recent laboratory model study directed toward the evaluation of creep of a circular plate anchor embedded in a soft saturated clay. The model tests were conducted in one type of clay using only one model anchor.

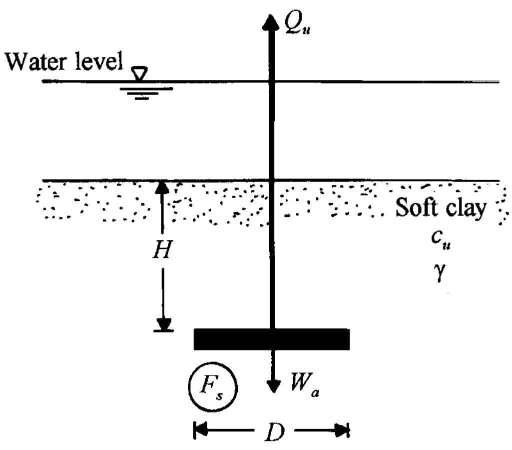

Fig. 1 Circular plate anchor embedded in soft saturated clay

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KEY WORDS: Plate anchor, creep, soft clay, net load, rate of strain.