PULLOUT CAPACITY OF VERTICAL

ANCHORS IN CLAY

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To my wife

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by

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THESIS

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NOTATIONS

A = Area of anchor plate

B = Width of anchor plate

B = Width of foundation

B_e = Equivalent width of each anchor plate in a series

c_u = Undrained shear strength

F_c = Breakout factor for anchors in clay

$F_{c(max)}$ = Maximum value of breakout factor for anchors in clay

F_q = Breakout factor for anchors in sand

F_s = Shape factor

H = Depth of embedment of anchor plate

h = Height of anchor plate

K_a = Active earth pressure coefficient

K_γ = Earth pressure coefficient

L = Length of foundation

$M_{\gamma q}$ = Force coefficient

m = Shear strength mobilization factor

N_c = Bearing capacity factor for deep foundations

P = Working load

P_{aN} = Normal component of the active force

P_{aT} = Tangential component of the active force

P_{pN} = Normal component of the passive force

P_{pT} = Tangential component of the passive force

P_u = Ultimate load

P_u = Ultimate pullout resistance

NOTATIONS (continued)

P_u^o = Ultimate pullout resistance for the 'basic case'

P_u^s = Ultimate pullout resistance for the 'strip case'

S = Spacing of anchor plates in a series

s = Mobilized shear strength

W = Weight of strip anchor per unit width

α = Parameter relating breakout factors of anchors in clay

β = Parameter relating embedment ratios of anchors in clay

γ = Unit weight of soil

Δ = Anchor displacement at working load

Δ_u = Anchor displacement at ultimate load

δ_γ = Soil-anchor friction angle

σ_o = Normal stress

ϕ = Soil friction angle

Chapter 1

INTRODUCTION

Vertical square and rectangular anchor plates are often used in many earth retaining structures such as retaining walls and sheet pile bulkheads. They are also used at pipeline bends. During the past ten to fifteen years, a number of experimental and theoretical investigations have been conducted to estimate the ultimate pullout resistance of vertical anchor plates (Fig. 1.1) embedded in sand. The results of most of the work as related to the ultimate resistance of vertical anchors in sand can be found in the papers of Ovesen (1964); Ovesen and Stromann (1972); Neeley, Stewart and Graham (1973); Das (1975); Das and Seeley (1975); Das, Seeley and Das (1977); Hueckel (1957), and Kostuykov (1967). However, a closely related topic, i.e., the estimation of the ultimate pullout resistance of vertical anchor plates embedded in saturated or near saturated clayey soils has received very little attention by geotechnical engineers in the past. The only work in this area so far reported in literature is that of Mackenzie (1955) which was conducted in the course of his master's thesis at Princeton University. Mackenzie's study was only related to strip vertical anchor plates. The ultimate pullout resistance of strip anchors was determined in two different clays. A summary of this study has been reported by Tschebotarioff (1973).

In practice, however, most vertical anchor plates are square or rectangular in shape, i.e., $B/h \leq 5$ (where B = width of anchor plate;

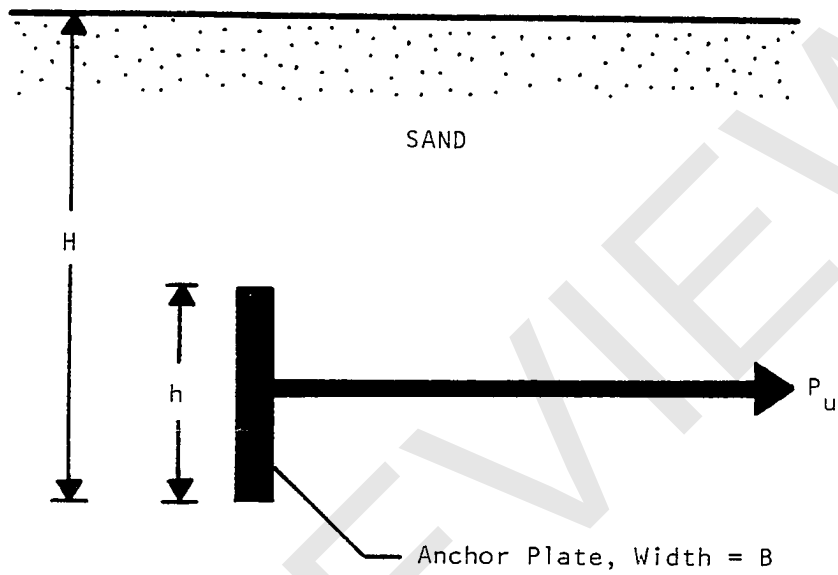

Fig. 1.1 Vertical Anchor Plate - General Parameters

h = height of anchor plate as shown in Fig. 1.1). Vertical anchors with B/h $\geq$ 5 are considered to be equivalent to strip anchors. A review of the existing literature shows that no work has yet been done to evaluate the ultimate pullout resistance (P_u) of rectangular anchor plates with width-to-height ratios of less than five, and embedded in a saturated and near saturated clay soil.

The purpose of the present study is to conduct several small scale laboratory model tests in clay to evaluate the ultimate resistance of rectangular anchors with B/h = 1, 2, 3 and 5. Based on the experimental results, an attempt has been made to present a semi-empirical relationship to estimate the magnitude of the ultimate resistance (P_u) of rectangular anchors in saturated clay.