

# Ultimate Uplift Capacity of Metal Piles in Sand

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## ABSTRACT

Ultimate uplift capacity of piles embedded in sand depends upon, among other factors, the friction angle developed at the soil-pile interface. The soil-pile interface friction angle depends on the properties of sand and the smoothness of the pile surface. The paper presents some laboratory model test results for the ultimate uplift capacity of an aluminum pile with a relatively smooth surface. Based on the laboratory results, the variation of the unit skin friction with embedment ratio has been calculated. Using the present as well as the existing model test results with piles having rough surfaces, the range of parameters required for estimation of the ultimate uplift capacity of piles in sand has been presented.

## INTRODUCTION

Analysis of single and group piles subjected to compressive loading has received much attention in the past. Based on the existing studies, design and construction of piles with compressive loading can now be accomplished with a relatively greater confidence. However, in many offshore construction works, piles are designed for both compressive and tensile loading. In many situations, the tensile loading may become critical for design. At present, relatively few studies have been documented in the literature directed toward the estimation of the ultimate uplift capacity

of piles embedded in sandy and/or clayey soils. This paper relates to the resistance to axial uplifting load of straight shafted vertical metal piles in sand.

## REVIEW OF EXISTING STUDIES

The ultimate uplift capacity of a pile (Fig. 1) may be expressed as:

$$Q_u = Q_o + W \quad (1)$$

where  $Q_u$  = gross ultimate capacity,  $Q_o$  = net ultimate capacity, and  $W$  = effective self-weight of the pile.

The net ultimate uplift capacity of model piles embedded in sand has been evaluated in the laboratory by Das (1983); Das and Seeley (1976); Das, Seeley and Pfeifle (1973); Chaudhuri and Symons (1983); and a few others. However, in practically all cases, the surfaces of the model piles used for the tests were made rough by coating them with a layer of sandpaper. In some cases, the surfaces were first coated with glue, then rolled in sand and dried.

Meyerhof (1973) proposed a simple theoretical expression for estimation of the ultimate uplift capacity of piles embedded in sand. According to Meyerhof's theory:

$$Q_o = K_u \sigma_v A_s \tan \delta \quad (2)$$

where  $K_u$  = uplift coefficient,  $\sigma_v$  = average effective overburden pressure,  $A_s$  = surface area of the pile,  $\delta$  = angle of friction at the soil-pile interface.

The average effective overburden pressure is:

$$\sigma_v = \frac{1}{2} \gamma' L \quad (\text{in submerged sand}) \quad (3a)$$

and:

$$\sigma_v = \frac{1}{2} \gamma L \quad (\text{in dry sand}) \quad (3b)$$

where  $\gamma'$  = effective unit weight of sand,  $\gamma$  = dry unit weight of sand, and  $L$  = length of the pile.

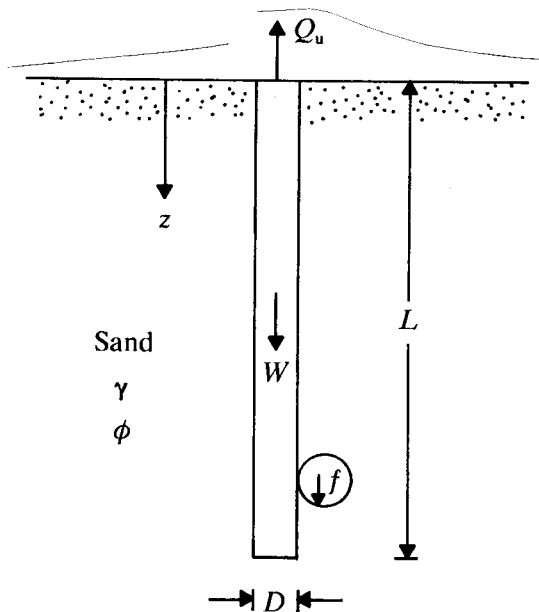


Fig. 1 Vertical circular pile in sand subjected to uplifting load

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