Hyperbolic Relationship for Axial Load-Displacement Behavior of ACIP Piles

O. Guvener and C. Vipulanandan

Center for Innovative Grouting Materials and Technology (CIGMAT)
Department of Civil and Environmental Engineering
University of Houston, Houston, TX 77204-4003
Tel: 713-743-4291; email: oguvener@uh.edu

Abstract

In order to develop a simple relationship to predict the axial load-displacement behavior of ACIP piles, a two parameter non-dimensional hyperbolic relationship was investigated to represent the non-linear load-displacement behavior of piles. The relationship was verified using a full scale load test data.

1. Introduction:

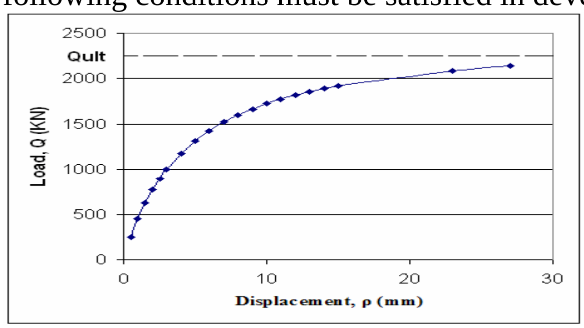
The axial load- displacement relationships are nonlinear and are tested to twice the design load. This limits the displacement to which the pile is tested and requires an extension to load-displacement relationship to determine the ultimate bearing capacity. Chin et al. (1970, 1978) had used hyperbolic relationship to estimate ultimate capacity of piles, when load tests did not reach failure load and to investigate defects in driven piles. Kulhawy et al. (2004) have modeled the load-displacement relationship using linear and nonlinear segments. Vipulanandan et al. (2005) have used the non-dimensional hyperbolic relationship to predict the behavior of ACIP piles in soils. The entire system of pile material, soil and soil pile interaction are nonlinear and hence initial load displacement relationship will be nonlinear as observed in different studies.

2. Objectives:

To develop and verify a simple model to predict the load-displacement relationship for ACIP piles in soils.

3. Analysis and Discussion:

Based on the inspection of the load displacement relationships for the ACIP piles, the following conditions must be satisfied in developing a mathematical relationship.



When $\rho \geq 0 \Rightarrow \dfrac{dQ}{d\rho} > 0$, $\dfrac{d^2Q}{d\rho^2} < 0$

When $\rho \rightarrow \infty$ $\dfrac{dQ}{d\rho} = 0$, $Q \rightarrow Q_{ult}$

Fig 1. (ACIP pile full scale load test located in Crosby, Texas (mixed soil profile))

One mathematical relationship that will satisfy these conditions is the hyperbolic equation which can be represented as follows:

$$Q = \frac{p}{A + B\rho} \qquad (1)$$

The hyperbolic relationship is preferred over exponential and bi-linear relationships due to the simplicity in using the equation and correlating of the two parameter to geotechnical properties at the pile location. One way to verify the applicability of Equation (1) to the load-displacement test data is to rearrange the equation to represent a linear relationship ass follows:

$$\frac{\rho}{Q} = A + B\rho \tag{2}$$

If the pile test data can be represented by a linear relationship (Eqn.(2)) within acceptable limit (high coefficient of correlation), then it can be stated that the load- displacement relationship is hyperbolic. Parameters A and B can be obtained from the linear relationship.

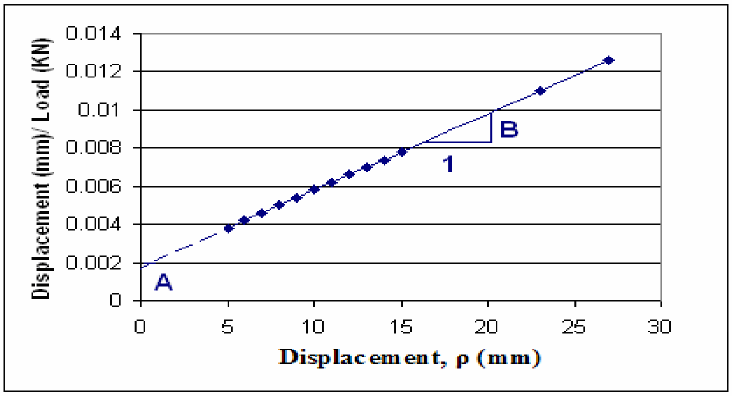


Fig 2. Verification of hyperbolic relationship for ACIP pile

When the displacement becomes large the pile capacity reaches its theoretical maximum (Qult) and it will be related to the parameter as follows:

$$Q_{ult} = \frac{1}{B} \tag{3}$$

The parameter A is the reciprocal of initial tangent (Equation (1)) but the initial tangent is not very easy to determine since it is very sensitive to the construction method. Hence another approach to estimate the parameter A has been suggested by Vipulanandan et al

4. Conclusions:

Based on the analysis, hyperbolic relationships can be used to represent the load-displacement relationship of ACIP pile.

5. Acknowledgement:

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6. References:

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