Re-analysis of Piled Raft Foundation of
a Building in Osaka

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Abstract: The piled raft foundation of a building in Osaka is reanalysed. The computed values obtained by the theoretical and empirical formulas for calculating the negative friction of single pile presented in this paper are close to the measured. Meanwhile the method to predict the settlement of piled raft foundation is also presented.

1. Introduction

A building is a 14-story residential apartment rising 49.22 m above street level which founded on the piled raft foundation, 58.8m x 27.8m, 200 steel pipe piles of diameter, 1m, 60m long and 2.8 - 3m spacing and was instrumented and monitored since its construction in 1977. A great deal of field measurements including negative friction of pile and settlements was made.

2. The theoretcial formula for calculating negative friction of single pile is presented as follows (Fig. 1):

$$F_n = F_{n(1)} + \frac{1}{n'} \sum_{i=2}^{n} \left[\gamma'(z_i - z_{i-1}) + \left(\frac{\gamma_i^*}{m_i} - p_0\right)\left(e^{-m_i z_i} - e^{-m_i z_{i-1}}\right)\right] \tag{1}$$

where

$$F_{n(1)} = \frac{1}{n'} \left[p_0 + \gamma' z_1 - \frac{\gamma_1^*}{m_i}(1 - e^{-m_1 z_1}) - p_0 e^{-m_1 z_1} \right]$$

p_0 = surcharge on the base of foundation
m = $n' U K_0 \tan\phi'$
n' = number of piles in unit area
K_0 = coefficient of earth pressure at rest
$\gamma^* = \gamma' - n' U c'$
γ' = buoyant unit weight of soil
ϕ' = effective friction angle of soil
c' = effective cohesion
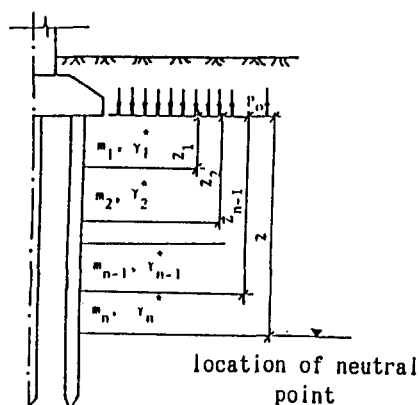U = periphery of pile.

location of neutral
point

Fig. 1 Calculation of negative friction

3. The empirical formula is :

$$F_n = \xi (p_0 + \gamma'z) \tag{2}$$

where

$\xi = 0.25 - 0.35$

or $\xi = 0.3$ for convenience of estimation

$\gamma' =$ buoyant unit weight of soil

$p_0 =$ surcharge on the base of foundation.

4. The location of neutral point can be readily determined by the trial and error method or assumed at $0.7L - 0.9L$, L is the length of pile.

5. A comparison of calculated and measured values is listed in Table 1.

Table 1 Comparison of calculated and measured values

Theoretical value	878.66 tf
Empirical value ($\xi = 0.30$)	929.50 tf
($\xi = 0.25$)	774.58 tf
Measured value	940.00 tf

Note: The measured depth of neutral point is located at 49.3 m.

6. The preliminary idea for calculating settlement of pile group considering negative friction suggested in this paper is that the ratio of bearing capacity of pile to calculated load should be greater than 1.5 , i.e. the factor of safety, $K \geqq 1.5$, otherwise the settlement of building will continue to increase and lead to decrease the negative friction until $K \geqq 1.5$.   Now, the ultimate bearing capacity of pile, $[P] = 792$ tf, the calculated load acting on pile, $P = 604$ tf corresponding to measured settlement, $S = 60$ mm, the factor of safety, $K = 1.3$, the predicted settlement will be over 80 mm.   The measured vaule is about 80mm.

7. Conclusions

Eqs.(2) and (1) can be used in preliminary and design stages, respectively for calculating negative friction of pile foundation. It is not necessarily to carry out the test for measuring negative friction of pile , and a great deal of money can be saved. The method to predict the settlement can be used in practice, however, the further study should be needed.

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