Vertical Capacity of Large and Deep Barrette Pile for Bangkok Subsoils

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Abstract. Recently, barrette piles have been used to replace conventional bored piles in order to increase allowable vertical pile capacity in the limited space projects such as high-rise building projects and elevated train projects. The basic of construction equipment, the slurry used during construction and construction time between barrette pile and bored pile construction are totally different. Therefore, their design parameters for pile capacity estimation should be different. In this research, pile load test was carried out on the fully-instrumented barrette piles. The test result can be separated into friction of each soil layer and end bearing. By considering stress-strain relationships, adhesion factor of clay layer, friction factor of sand layer and end bearing factor of sand layer can be calculated. These factors were found to be able to estimate ultimate pile capacity. Based on these factors, the estimated pile capacity was compared with another barrette pile tests. This estimation agreed well with the test results.

Keywords: Barrette pile · Pile capacity · Adhesion factor · Friction factor

1 Introduction

Recently, the barrette pile has been used to replace the conventional bored pile in Bangkok city since it provides higher capacity in the limited space. The construction process of a barrette pile is the same as that of a diaphragm wall but it is different from wet process bored pile. The bentonite slurry is used as borehole stabilized agent during boring of the barrette which is different from wet process bored pile which polymer based slurry is used (Teparaksa and Teparaksa 2012). The bentonite slurry creates the cake film along the shaft of borehole and sedimentation at pile toe which leads to a decrease in shaft friction and end bearing (Teparaksa 1994, 2000, Teparaksa et al. 1999). This paper presents the behavior of deep barrette pile constructed in Bangkok subsoil based on the recent fully instrumented test piles.
2 Soil Condition

The Bangkok subsoils consists of 13–16 m thick of soft to medium clay and followed by a stiff clay layer to about 21–28 m deep. The first dense silty sand layer is encountered below stiff to hard silty clay. The very stiff silty clay is alternated with the second dense silty sand layer at about 45–55 m deep. Generally, pile foundation of superstructure is penetrated in this second very dense sand layer. The piezometric level or phreatic surface of Bangkok aquifer is drawdown from −23.0 m below ground surface in 1995 and increased to −13.0 m in 2016.

3 Shaft Friction Behavior of Deep Barrette Pile

The deep barrette pile has been used for many years in Bangkok city; however, only 12 tested deep barrette piles with fully instrumentation had been collected. The barrette pile tip mostly penetrated in the second very dense silty sand layer at the depth of 50–60 m. All barrette piles were not based grouted. The unit pile shaft friction ($f_s$) can be estimated from the following equations;

$$ f_s = \alpha S_u \text{ (for clay layer)} \quad \text{and} \quad f_s = \beta \sigma'_v \text{ (for sand layer)} $$

where

- $f_s$ = Unit pile shaft friction (kN/m²)
- $S_u$ = Undrained shear strength of clay (kN/m²)
- $\sigma'_v$ = Effective overburden pressure in drawdown condition (kN/m²)
- $\alpha$ = Adhesion factor for clay
- $\beta$ = Friction factor for sand

$\alpha$ and $\beta$ value can be determined from load transfer curve derived from instrumented test barrette piles which consists of vibrating wire strain gauges and extensometers installed near to the boundary of each soil layer. The $\alpha$-value derived from

![Fig. 1. Adhesion factor and undrained shear strength of barrette pile.](image-url)
mobilized skin friction of all collected barrette pile test is presented against undrained shear strength of clay layer in Fig. 1. The relationship between $\beta$-value and effective angle of internal friction ($\phi'$) of the sand layer derived from instrumented pile load test is presented in Fig. 2.

**Fig. 2.** Friction factor and angle of internal friction of barrette pile

**Fig. 3.** $N_q$-parameter of barrette pile
4 End Bearing Behavior of Deep Barrette Pile

The bearing capacity of a barrette pile with tip penetrated in the sand layer generally derived from the same approach as bored pile as Eq. 2:

\[ q_b = N_q \sigma'_v \]  

(2)

where

- \( q_b \) = Unit end bearing (kN/m\(^2\))
- \( N_q \) = End bearing coefficient
- \( \sigma'_v \) = Effective overburden pressure in drawdown condition (kN/m\(^2\))

The mobilized \( N_q \)-parameter of tested barrette pile is based on the pile deflection at the point where the tested load closes to the yield point of Butler & Hoy or Mazurkiewicz methods defined by Fellenius (1980) as presented against effective angle of internal friction of sand layer in Fig. 3.

5 Back Analysis of Barrette Pile Capacity Without Instrumentation

To verify the proposed \( \alpha, \beta \) and \( N_q \) parameter for determination of ultimate capacity of deep barrette pile, pile capacity of two tested barrette piles without instrumentation, BP-T1 and BP-T2, was estimated and compared with pile load test. As present, BP-T2 is the deepest barrette pile (71.0 m deep) in Thailand. Table 1 presents the result of comparison. It was found that the calculated or estimated ultimate pile capacity agreed well with test results.

<table>
<thead>
<tr>
<th>No</th>
<th>Project</th>
<th>Dimension (m)</th>
<th>Length (m)</th>
<th>Max. test load (tons)</th>
<th>Back analysis of pile capacity (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP-T1</td>
<td>MRT blue line extension</td>
<td>0.80 × 2.70</td>
<td>55.0</td>
<td>2,750</td>
<td>3,170</td>
</tr>
<tr>
<td>BP-T2</td>
<td>Landmark waterfront</td>
<td>1.00 × 2.70</td>
<td>71.0</td>
<td>5,150</td>
<td>5,124</td>
</tr>
</tbody>
</table>
6 Conclusions

The behavior of deep fully instrumented barrette pile was investigated by full scale load tests in Bangkok subsoils. The skin friction factor $\alpha$ and $\beta$ value for barrette pile is determined from unit skin friction of strain gauges and extensometers installed in the test piles. The end bearing coefficient ($N_q$) was quite low due to the sedimentation at pile toe as a result of bentonite slurry. The verification of all parameters was carried out by predicting the ultimate capacity of another barrette pile test and comparing with its test results.

References

Teparaksa, W., Teparaksa, J.: Capacity of deep barrette piles with time effect. In: Proceedings of the 18th Southeast Asian Conference (18SEAGC) and Inaugural AGSSEA Conference (IAGSSEA), Singapore (2012)