Subject IDs: SA08, SI17
TC/ATC # (optional): ATC6

Performance of Reinforced Concrete Tank Raft with Upstand Ring Beam on Group Piles (12pt) (24 pt = 2 lines)

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(12 pt = 1 line) .
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(24 pt = 2 lines)

Keywords: Tank Raft, Ring Beam, Torsional Stiffness, Pile Heave, Soft Ground (up to six keywords)
(12 pt = 1 line)

This paper aims to share the project experience gained from massive grid patterned piling foundation supporting heavy tank farm structure on 5m thick reclaimed platform over 15m thick soft alluvial marine deposits consisting of inter-layered clay and sand, which is typically found in coastal areas of Peninsula Malaysia. The tank sizes range from 22.8m to maximum 54m in diameter and 20m to 22m in height. Due to tight project duration, no ground improvement was implemented for the reclaimed ground.

Numbers of construction problems were observed during construction and are summarized below.

a. Observable excess pore water pressure within the soft marine clay probably generated from massive piling of large displacement piles (Figure 1).
b. Pile heaves (Figure 2), pile deviation and joint dislodgement due to soil movement induced by rapid insertion of massive large displacement piles in grid pattern into the incompressible soft marine clay (Liew, et al, 2010).
c. Tensile cracking (Figure 3a) of upstand ring beam on tank raft on group piles under inward torsional action by the integrated raft with bowl-shaped raft deformation during hydrotest. The irrecoverable bowl-shaped raft deformation with detachment of tank roof support upon unloading (Figure 3b) is the consequential effect of pile-soil group interaction effect under heavy hydrotesting.
d. Consolidation settlement of lower alluvial deposits underlying the reclaimed platform (Figure 4).
e. Design consideration of downdrag force on pile foundation due to aforementioned settling platform.

Some of the above phenomena can either visually observed or detected by survey monitoring and indirect testing. With these problems in hand, solutions and precautionary measures were recommended to minimize the adverse effect during the project execution. Despite saturated marine clay is considered as soft compressible materials traditionally and intuitively, but actually behaves as undrained material during the rapid insertion of massive number of large displacement piles, thus behaving in incompressible manner with full soil displacement. The perceived compressibility in the soft clayey soil is in fact the effect of consolidation process with volumetric reduction after dissipation of excess pore water from the loaded soil matrix. As such, care in planning the pile installation sequence from central outward direction with symmetrical driving pattern can minimize the net lateral soil displacement to avoid adverse pile deviation. Whereas for the pile heave, larger pile spacing and driving the set pile were executed to re-establish good end bearing pile contact to restore pile capacity at the earlier end-of-drive. These improvements were significant in overcoming the magnitude of the said problems.

In view of the structural restraint of the upstand ring beam to the tank raft supported on grid patterned pile foundation, theoretical structural model was developed for determining the torsional stiffness of the ring beam with inward torsional action from the tank raft, the induced moment developed along the ring beam and to explain the tensile crack pattern will be presented in this paper.

Fig. 1. Water Overflowing in Pile Annulus as Evidence of Excess Pore Water Pressure in the Ground (9pt, left aligned)

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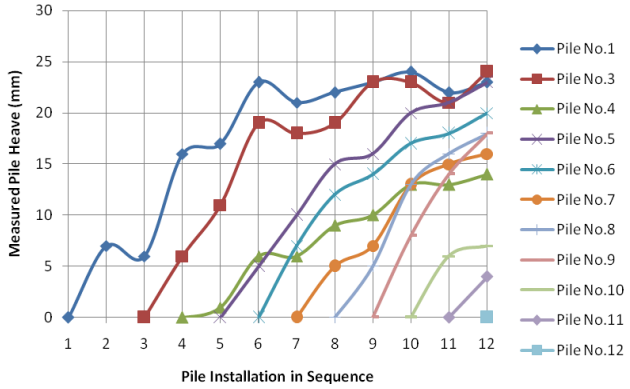

Fig. 2. Pile Heave Monitoring of 12 Pilot Piles (9pt, left aligned)

Fig. 3a. Tensile Cracking on Upstand Ring Beam during Hydrotest (9pt, left aligned)

Fig. 3b. Detached Tank Roof Support due to Irrecoverable Bowl-Shaped Tank Raft Deformation after Hydrotest (9pt, left aligned)

Fig. 4. Settlement of Reclaimed Platform (9pt, left aligned)

REFERENCES (if needed, 10.5pt upper case, bold)

Liew, S. S., Ting, D. I. and Low, Y. H. (2010). Piling Foundation Design & Construction Problems of Tank Farm in Reclaimed Land over Untreated Soft Marine Clay in Malaysia. The 17th Southeast Asian Geotechnical Conference, Taipei, Taiwan, May 10~13, 2010 (9pt)