

Liner Piles Used as Support to Kentledge for Initial Compression Load Test



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Abstract The initial pile load tests are conducted to ensure the geotechnical capacity of the pile in a particular site condition. Normally kentledge method is adopted for the compression pile load tests. In this method the entire kentledge load is loaded above secondary beams which are supported by concrete blocks above the Natural Ground Level. So, it is important to ensure the SBC (for shear and settlement) of the natural ground. In one of our projects initially it was decided to go with the kentledge system for the initial compression load test on a 56 m long 1200 mm diameter BCIS pile. The test load and total kentledge load were 2160t and 2700t, respectively. The soil strata mainly consisted of clay with a low SPT N value and a water table almost at ground level. It was suggested to replace top soil using a Granular Sub-base (GSB) with good compaction in order to avoid excessive settlement of concrete blocks placed to support the kentledge weight. When the kentledge loading started, even before reaching 10% of the total kentledge load, an excessive settlement on the GSB layer was observed. This paper describes the problems faced during the normal kentledge method and how it was overcome using the liner pile system for initial compression load tests in this particular site condition for a higher test load.

Keywords Geotechnical capacity · Kentledge · Liner piles · Load test · Settlement

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1 Introduction

A variety of methods are there to determine the load bearing capacity of piles that might be either analytical or empirical. The former requires an evaluation of soil and pile interaction along with several underlying assumptions. On other hand, the latter was based on outcomes from various in-situ test procedures. Generally pile load tests are conducted to confirm the design loads of pile obtained from empirical formulas. Before constructing the bearing piles at site, the design loads calculated theoretically need to be confirmed by conducting initial pile load test on initial load test piles. From the initial pile load test results, it was decided whether to redesign the pile or proceed construction with existing design data. Compression pile load tests normally carried out by two methods such as kentledge method or reaction pile method. This paper present the case study of initial pile load test conducted using kentledge type method where liner piles are used for kentledge support due to low SBC value of soil at existing ground level.

2 Project Scope and Stratigraphy

The project consisted of construction of pile foundation for 2 Nos of 89 m dia LNG tanks. Details of pile foundation for each tank are given in Table 1.

The soil profile of the project location shows that top 20 m is very soft clay. The site location is a filled-up area using dredged soil from sea. Due to the presence of very soft clay & loose sand strata for a depth of approximately 20 m, permanent steel casing is provided for working piles up to 24–30 m and pile is terminated in sand strata at 56 m in some locations and in other location pile is terminated at deeper depth of 61 m as dense sand strata is available after 60 m. Typical soil profile is shown in Fig. 1. Due to the presence of soft soil, it was decided to replace top 3 m soil with compacted engineering fill (GSB) for enhancing the lateral capacity of the pile.

Table 1 Details of pile foundation

Tank No	Type of pile	Pile dia (mm)	Pile depth (m)	Number of piles
Tank-01	BCIS	1200	58	242
		1200	63	194
Tank-02	BCIS	1200	58	204
		1200	63	232

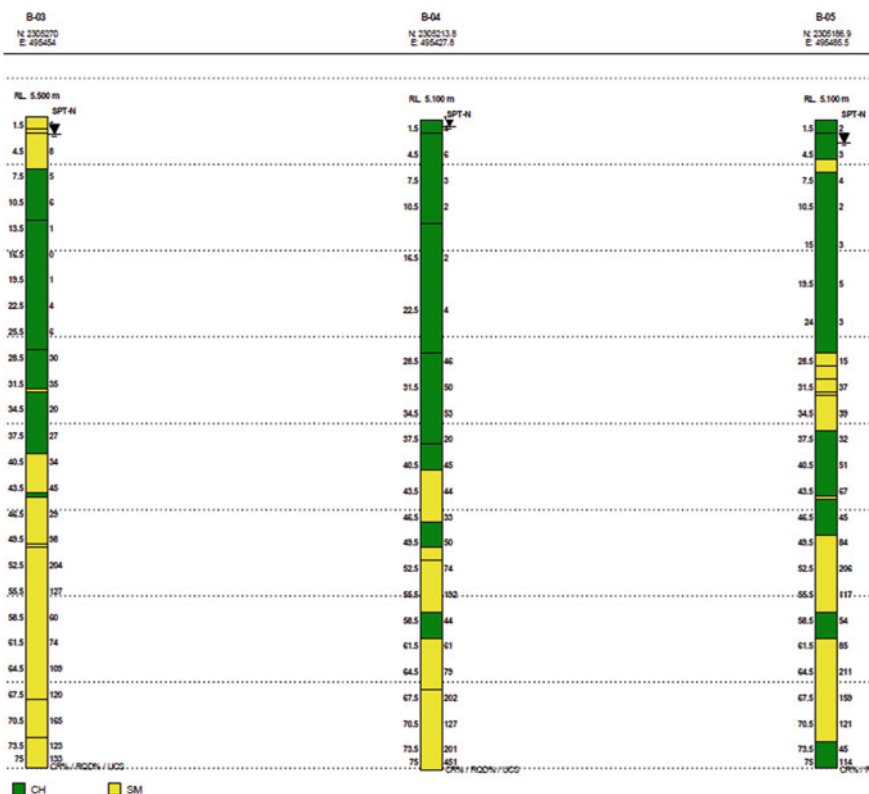


Fig. 1 Typical soil profile of site

3 Design Load and Initial Pile Load Test

Design load for the piles is given in Table 2.

To confirm the theoretical design load, it was proposed to carry out an initial compression load test at site near to the tank location. A total of 4nos of initial compression load test were proposed by the client. Due to huge test load (2160t) and availability of sufficient rebars and steel plates, kentledge system was adopted for initial compression load test as per IS 2911 Part 4: 2013. Figure 2 shows the initially proposed test scheme for the load test. The kentledge weight of 2700t is placed over

Table 2 Design load for pile foundation

Pile type	Pile dia (mm)	Pile depth (m)	Design load (MT)	
			Safe working load (SWL)	Negative skin friction (NSF)
BCIS	1200	56/61	800	80

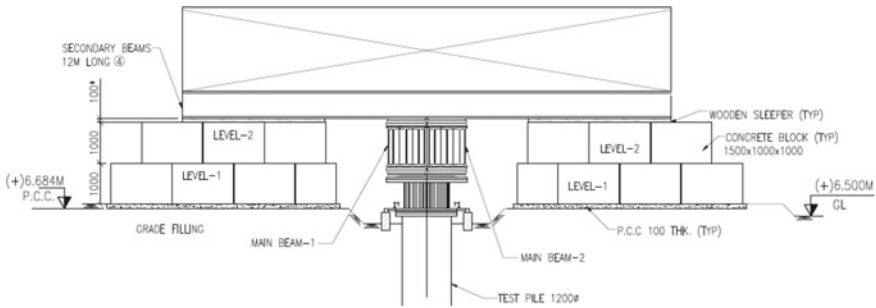


Fig. 2 Typical initial load test arrangement

48Nos of secondary beams which are supported by concrete blocks. The concrete blocks are placed over the GSB fill.

4 Site Issue in Initial Load Test and Solution

4.1 Site Issue

The base pressure acting on ground surface below concrete blocks on one side was 20 t/m^2 . From theoretical calculations the settlement for 20 t/m^2 was 75–80 mm. So, a gap of 100 mm was kept between the top of the hydraulic jack and the main beam. Since the soil below the GSB fill was soft, as the kentledge loading above secondary beams, the soil below concrete blocks started to settle. Before reaching 20% of kentledge, i.e., 500 t the concrete blocks settled about 95 mm, due to which the main beam also settled, and the main beam almost touched the hydraulic jack. So, from a safety point of view as the excessive settlement of soil will lead to serious accident hence the loading of kentledge was stopped and decided to unload the materials. Figure 3 shows actual site photo during the time of kentledge loading.

4.2 Solution

To overcome this excessive settlement, it was decided to support the kentledge above the liner piles instead of using concrete blocks. The 8 mm thick 1200 mm diameter liner piles were driven to a depth of 24 m using ICE-815 vibratory hammer of capacity 72 t. 16Nos of liner piles (8Nos on either side of test pile) were driven. The nearest liner pile is at a clear distance of 2.7 m from test pile. The plan of liner pile location and connecting beams are shown in Fig. 4. The liner piles were connected at top



Fig. 3 Load test arrangement in site using concrete blocks

using 4.5 m long built-up beam consisting of 6Nos of NPB 600 beams (Represented as Beam-3 in Fig. 5). Above these built-up Beam-3, another 16 m long built-up beam consisting of 4Nos of NPB 600 beams (Represented as Beam 4 in Fig. 5). Over this Beam 4, 48Nos of secondary beams are placed. The initial load test scheme using liner pile arrangement is shown in Fig. 5.

So, with this arrangement system the kentledge load from secondary beams is transferred to a dense stratum which is at about 20 m below EGL. The top levels of four corner liners were monitored using dumpy level at regular interval till the kentledge loading of 2616 t was completed. Figure 6 shows the actual site photo for the load test arrangement as discussed. The settlement of liner piles is monitored regularly.

5 Discussion on Liner Pile Settlement During Kentledge Loading

As discussed earlier, the kentledge weight is supported by 16Nos of liner piles. After final kentledge loading load coming on each liner is 167.5 t. With such a huge load on each liner the final settlement observed in liner piles was 16 mm on left side

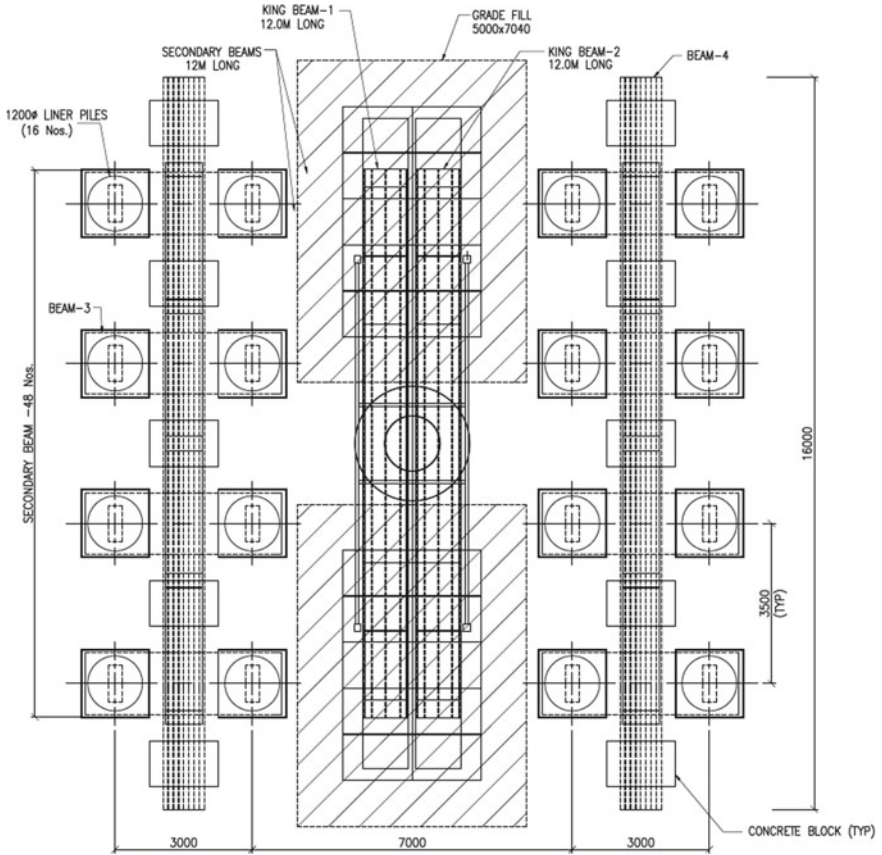


Fig. 4 Plan of load test arrangement using liner piles

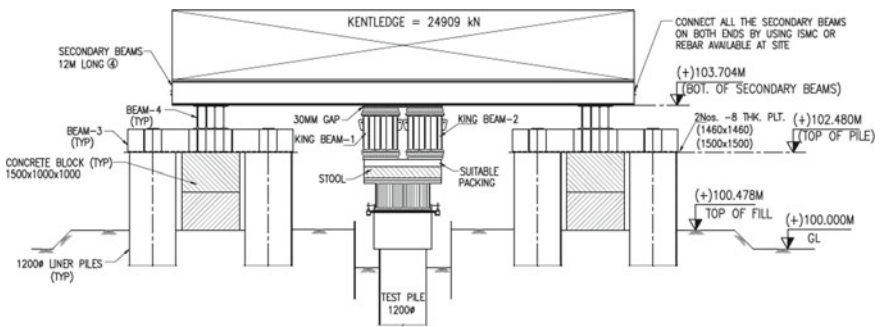


Fig. 5 Elevation of load test arrangement using liner piles



Fig. 6 Load test arrangement using liner pile as support to kentledge

and 20 mm on right side liners. Table 3 shows the left side and right side liner pile settlement at different stages of loading.

So, comparing with old load test proposal using concrete blocks as kentledge support, the liner pile system as support for kentledge was successful for heavy kentledge loads.

Table 3 Liner pile settlement at different stages of loading

Load-Settlement details for liner piles			
Total load (MT)	Load on each liner (MT)	Settlement (mm)	
		Left side	Right side
0	0.0	0.0	0.0
125.8	7.9	0.0	0.0
451.642	28.2	2.5	4.0
564.67	35.3	2.5	5.0
915.67	57.2	3.5	7.5
1283.7	80.2	4.5	8.0
1980.7	123.8	7.5	11.0
2679.7	167.5	16.0	20.5

Table 4 Test pile settlement during load test

% of load applied	Load applied (kN)	Settlement (mm)
0%	0	0
100%(SWL+2XNSF)	9720	16.35
0%	0	6.63
150%SWL+100%(2XNSF)	13,885	52.03
0%	0	36.7
200%SWL+100%(2XNSF)	17,356	123.35
0%	0	103.9

6 Discussion of Initial Pile Load Test Results

As mentioned above the test load for the initial load test is 2600t (250% SWL+100% 2xNSF). Load test was carried out in 3 cycles. First cycle with maximum load of 100% of design load applied in stages of 20% increment and each increment is maintained till rate of movement of pile top is not more than 0.2 mm/h or until 2 h have elapsed, whichever is earlier subject to minimum of 1 h (as per IS 2911 Part 4:2013). Second cycle applying load up to 150% in the same manner and in the third cycle applying load up to 250% and maintaining the final test load for 24 h.

In third cycle after applying a load of 17356kN (200% of SWL+100% of 2XNSF) the pile top settlement reached 123.35 mm (more than 10% of pile diameter) after 30 min of loading. So as per IS 2911 (Part 4): 2013, the loading was stopped and unloaded to zero.

The pile load test result was shared with the client and based on the result they have increased the number of piles in each tank as the actual capacity from the load test is less than the theoretical value (Table 4).

7 Conclusion

From the above data obtained during the load test following points can be concluded,

1. For pile load test with heavy kentledge loads, liner pile as support for kentledge weight will be safer compared to kentledge supporting on concrete blocks.
2. For sites where existing ground surface containing soft soil and having low SBC value, liner pile system is recommendable for kentledge type pile load test compared to use of concrete blocks as support to kentledge weight.

Reference

IS 2911 (Part-4) (2013) Design and construction of pile foundation – code of practice part 4 load test on piles