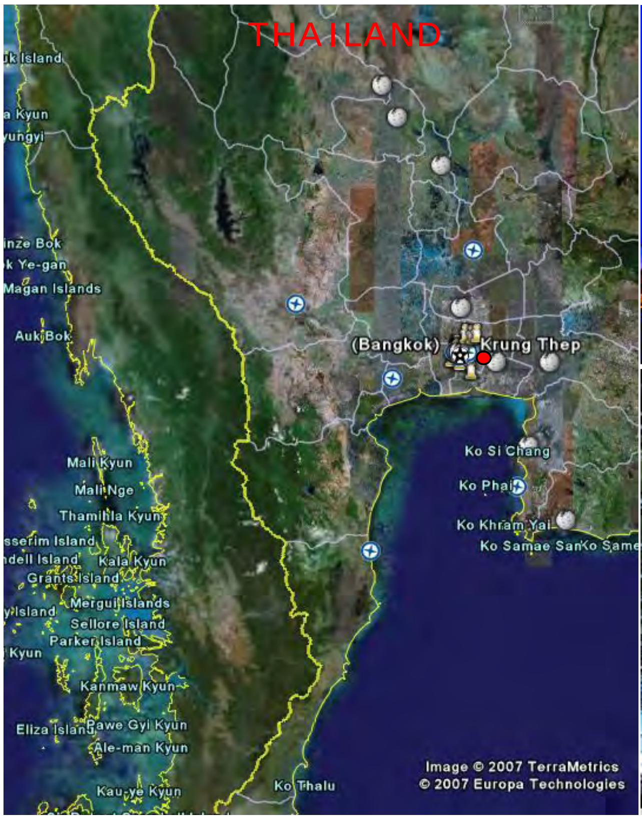


FELLENIUS, B.H., 2007. Bored Piles and bi-directional loading tests. Discussion. Journal of the Southeast Asian Geotechnical Society 38(2) 117-118.

Discussion

Bored Piles and Bi-Directional Load Tests

by S. Buttling,

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The author's paper is an informative presentation of the conditions, problems, testing, and analyses for the piled foundations of the very impressive Bangkok Airport project. However, while I agree with the author's critical views on the performance and results of the bi-directional tests, I find the critique misdirected. The critique of the method should better be directed toward the specific tester; the method itself is one of the most beneficial contributions to geotechnical engineering of the last twenty years.

The author has kindly provided me with the raw load-schedule information and strain-gage test data. Fig. 1 shows the load levels plotted against the recorded time for each set of readings. As the data are raw records, they do not include any note to explain why the load increments differed between the three stages, why Stage 2 included two unloading/reloading events, nor why the loads could not be maintained stable. It is patently obvious that if tests are to be compared to each other, it is important that loading schedules and increment magnitudes are kept as equal as possible, or the comparison will suffer. Moreover, the analysis of the strain-gage data turned out to be an exercise in futility. The strain-gages values are very erratic, as illustrated in Fig. 2, which shows the strains recorded during the third reloading of Stage 2 for the seven strain-gage levels. (The column to the right shows the pile with the relative location of the strain-gage locations). Establishing loads from such strain values would only be possible after considerable smoothing of data, and rejection and selection of values according to best judgment calls. In essence, the quality of the test data is considerably below standard, as indicated by comparing the appearance of the load-strain curves to more regular, more consistent records shown in Fig. 3. The latter shows strain data from a 66 m long, 610 mm diameter bored pile as imposed from a bi-directional cell at a depth of 40 m.

It must here be pointed out that the testing company at the subject project was not the internationally active company founded by Dr. Jorj Osterberg, the innovator of the Osterberg O-cell testing method.

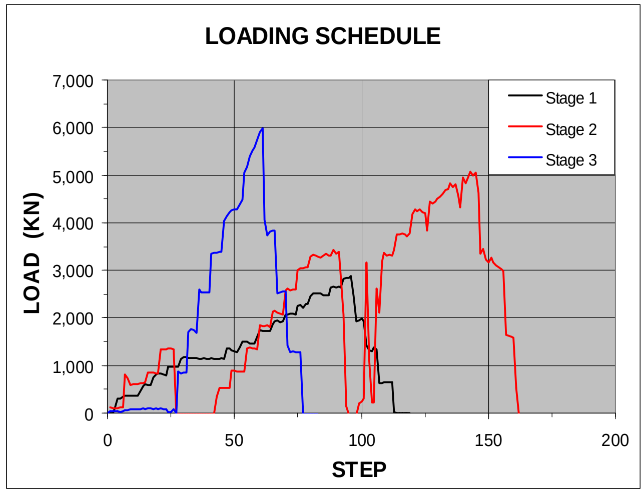

Fig. 1. Loading schedule

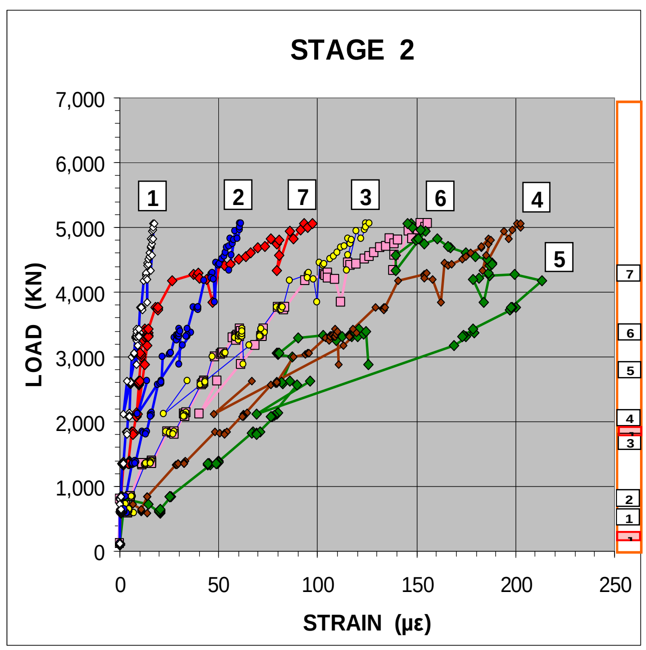

Fig. 2. Load versus strain recorded during third load application in Stage 2

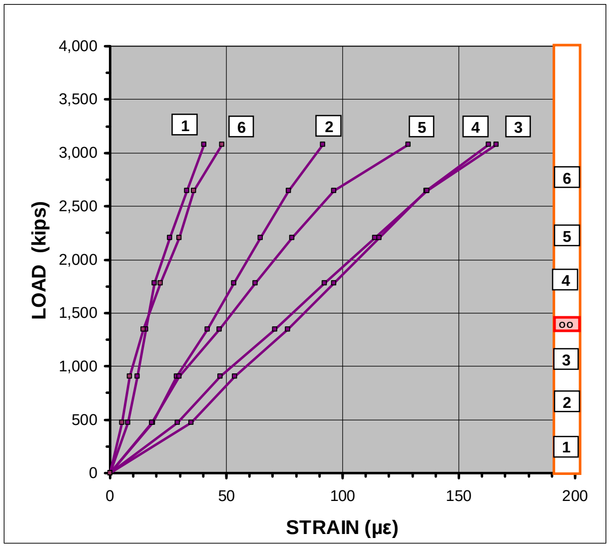

Fig. 3. Example of strains recorded in a 66 m long 610 mm diameter bored pile for Kahuku Bridge, Hawaii. O cell test performed by Loadtest Inc., Florida (data courtesy of Dr. Abidin Kaya, Hawaii DOT).

In contrast, the test data of the hydraulic jacks are not useless, however. Fig. 4 shows downward load-movement recorded for the bottom jack plates in the three bi-directional tests. Stage 1 is the load-movement of the pile toe alone, while Stage 2 is the load-movement (shaft resistance response) below the upper jack alone (toe jack is kept open so that the pile toe provides no resistance to imposed movement). Stage 3 is the load-movement of shaft below the upper jack, and, as the jack is now closed, the imposed movement mobilizes toe resistance. The author writes that "*although the base* (pile toe) *alone* (Stage 1) *produced a resistance of about 3,000 KN, and the middle section (Stage 2) alone about 5,000 KN, the two combined tests* (Stage 3) *only managed to produce a reaction of 6,000 KN*". However, the results of the three tests are really not in conflict with each other.

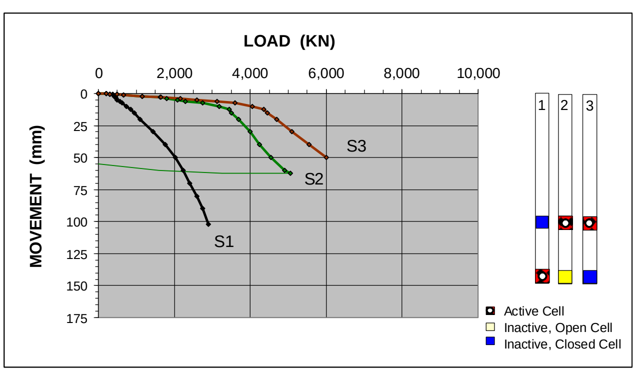

Fig. 4 Downward load-movement of upper and and lower jack plates: Stages 1, 2, and 3.

A comparison of the results of Stage 3 to that of a combination of the results of Stages 1 and 2, must consider the movements resulting from the applied loads, indeed, be according to a summation of the loads recorded at equal movement for each stage. Accordingly, Fig. 5 presents the Stage 3 load-movement results together with a curve constructed from the sum of the loads recorded in Stages 1 and 2 at equal movements (every about 2.5 mm). The curves are plotted starting at the net movement of Stage 2, i.e., 55 mm (the shortening of the pile was negligible). Because the maximum movement at Stage 2 was 62 mm, the combined curve is dashed beyond the imposed movement of 62 mm (i.e., 117 mm after the 55 mm starting point). The dashed portion is shown two ways, first assuming that the extrapolation of the Stage 2 load beyond the 62 mm (or 117 mm) to the maximum movement recorded for Stage 1 (102 mm and 157 mm) is either at a constant load value or extrapolated for increasing load per the observed trend of Stage 2 test. The results shown in Fig. 5 indicate a very close agreement between the load-movement of Stage 3 and the load-movement obtained by combining the results of Stages 1 and 2.

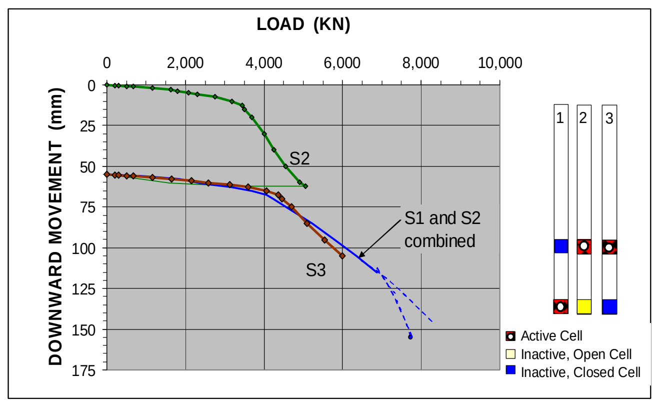

Fig. 5 Downward load-movement of upper and lower jack plates: Stages 2, and 3, and Stages 1 and 2 combined.

For clarification, Table 1 shows the loads at Specific Movements and at the Maximum and Net Movements in Figs. 4 and 5 ("Net" is movement after unloading to zero load).

The resistance above the upper jack was greater than the shaft resistance below the upper jack plus the toe resistance and, therefore, the ultimate shaft resistance above the upper jack could not be determined directly from the test. However, if the results would be correlated to the results of the conventional head-down static loading at the site tests, which established the shaft resistance in the upper portion of the piles, although not in the lower portion, the results of the bi-directional test are particularly useful. Indeed, a bi-directional test — well performed — provides the shaft and toe resistances as separate values and eliminates the uncertainty of the residual load (locked-in load) and its effect on the separation of shaft and toe resistance from strain-gage data.

Table 1 Loads at Specific Movements and at Maximum and Net Movements

Stage	Maximum Load (KN)	Movement Specific (mm)	Max (mm)	Net (mm)
Stage 1	2,000	50		
Stage 1	2,300	62		
	2,900		102	
	0			96
Stage 2	4,500	50		
Stage 2	5,000	62		
	0			55
Comb. 2+3	0	0/ 55		
Comb. 2+3	6,300	50/105		
Comb. 2+3	6,900	62/117		
Comb. 2+3	8,000	102/157		

The author presents the concept of the method adopted for designing the piled foundations at the site. However, the method was not first proposed in 1996, but 12 years earlier (Fellenius 1984). It has been further detailed by Fellenius (2004). Moreover, in my opinion, the author's term "*concept of neutral plane*" does not convey the main principle of the method, that of combining load and resistance distribution with the soil settlement distribution. My preferred term is "*unified method of design for capacity, drag load, settlement, and downdrag*", "*the unified method*" for short.

References

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