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VARIATION OF CAPACITY WITHIN A PILE GROUP

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It is often taken for granted that piles will have the same capacity if the following conditions are at hand:

- the piles are of the same material, type, and size
- the piles have the same embedment length
- the piles (driven) have the same final penetration resistance
- the piles are installed in the same group or in the vicinity of each other in a soil which can be justifiably claimed to be the same for the piles

Thus, the capacity of one pile chosen at random is considered representative for the capacity of all other piles. Most engineers know that this statement is somewhat unfounded. Therefore, when selecting a test pile in engineering practice, the pile which is believed to be the poorest is normally chosen. This ensures that one "errs" on the safe side.

When evaluating the performance of a piling project, the approach is acceptable. However, when performing a special study, for instance comparing different methods of capacity evaluation, such as static versus dynamic, it is not advisable to apply one method to one pile and the other to another pile. Agreement or disagreement may be very fortuitous, only, as illustrated in the following two case histories.

CASE 1

At a site in Southern Ontario, static loading tests were performed on three closed-toe pipe piles of 324 mm diameter (12.75 inches) and 9.5 mm (0.375 inches) wall thickness. The piles were driven through 20 metre (60 feet) of fill and clay and about 6 metre (20 feet) into a very dense silt till (Fellenius et al., 1978). A Delmag D-22 hammer was used to drive the piles to a "refusal", defined for the project as an end-of-driving penetration resistance exceeding 300 blows/0.3 metre.

Three piles at the site were selected for static testing. The piles were installed near each other and could be expected to behave similarly under load. Fig. 1 presents the load-movement curves obtained in the static testing. The value and location of the Davisson offset limit loads are indicated at each curve. For the three piles, the offset limit loads ranged from a low of 2,845 KN (320 tons) to a high of 3,825 KN (430 tons); the high value being 35 % greater than the low value.

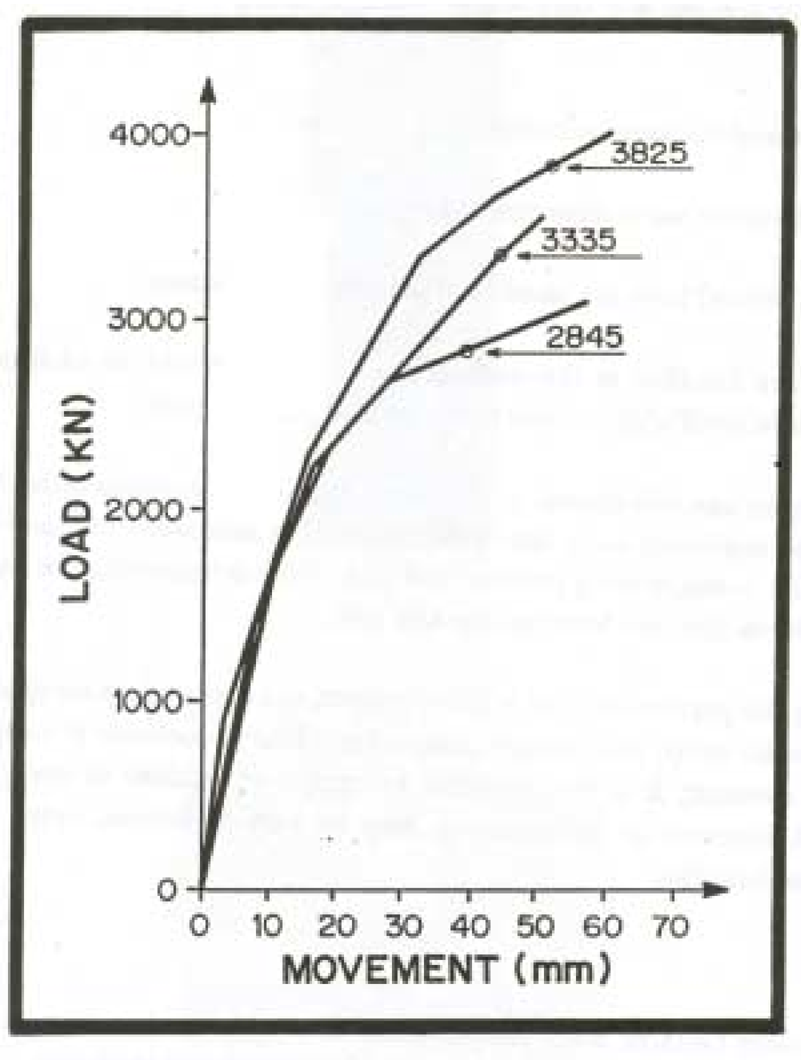

Fig. 1 Load-Movement Curves from Static Loading Tests

CASE 2

At a site near Three Rivers, Quebec, a group of nine piles were driven through about 10 metre (33 feet) of loose to compact silty sand and about 2.5 metre (6 feet) into a dense silty sand with gravel. The piles consisted of closed-toe pipe piles with 273 mm diameter (10.75 inches) and 5.8 mm (0.23 inches) wall thickness and were driven by means of a 27 KN (3 tons) drop hammer with a 0.9 m (3 feet) height of fall. The assigned allowable load for the piles was 490 KN (55 tons).

The beginning-of-restriking penetration resistances for the piles ranged between 100 and 300 blows/0.3 metre. All piles were subjected to dynamic monitoring and a static loading test was performed on one pile. Before performing the static test, the test pile was subjected to a series of restrikes using different heights of fall. These restrikes caused the pile to penetrate additionally about 0.2 metre into the dense sand. The static test result, offset limit load of 1,070 KN (120 ton), was used to calibrate the end-of-restriking (EOR) pile capacity, according to the Case Method Estimate (CMES), which determined the damping factor, J, to 0.10.

The thus calibrated J-factor was used to determine the CMES capacity for all piles at beginning-of-restriking (BOR). For the test pile, the beginning-of-first-restrike (BOR1) capacity was 790 KN (89 tons). For the other piles, the BOR values ranged from a low of 660 KN (74 tons) to a high of 1,040 KN (117 tons); the high value being 58 % greater than the low value.

The results have been illustrated in Fig. 2 showing a plan view of the group with the CMES values indicated. Below the plan view, the capacities are plotted along a scale showing both the actual value in KN (tons) and in terms of factor of safety (ratio of capacity to allowable load).

As shown in Fig. 2, the mean value of the pile capacities was 855 KN (96 tons), which corresponds to an average factor of safety of 1.75. The standard deviation was 119 KN (13 tons), which is 14 % of the mean capacity.

The engineer in charge of the project was pleased with the outcome of the static loading test taking it as "proof" of that the piles in the group had an adequate capacity and did not concern himself with the result of the dynamic testing. One might reflect over what the situation might have been had the test pile not been restruck to the higher capacity or if any other pile had been selected for static testing.

For one pile, the factor of safety was smaller than 1.5. Generally, such a low value would raise serious concern if found in a static loading test on a pile chosen at random. For the subject case, the average factor of safety of 1.75 determined by means of the dynamic monitoring indicate clearly that the capacity of the group was adequate.

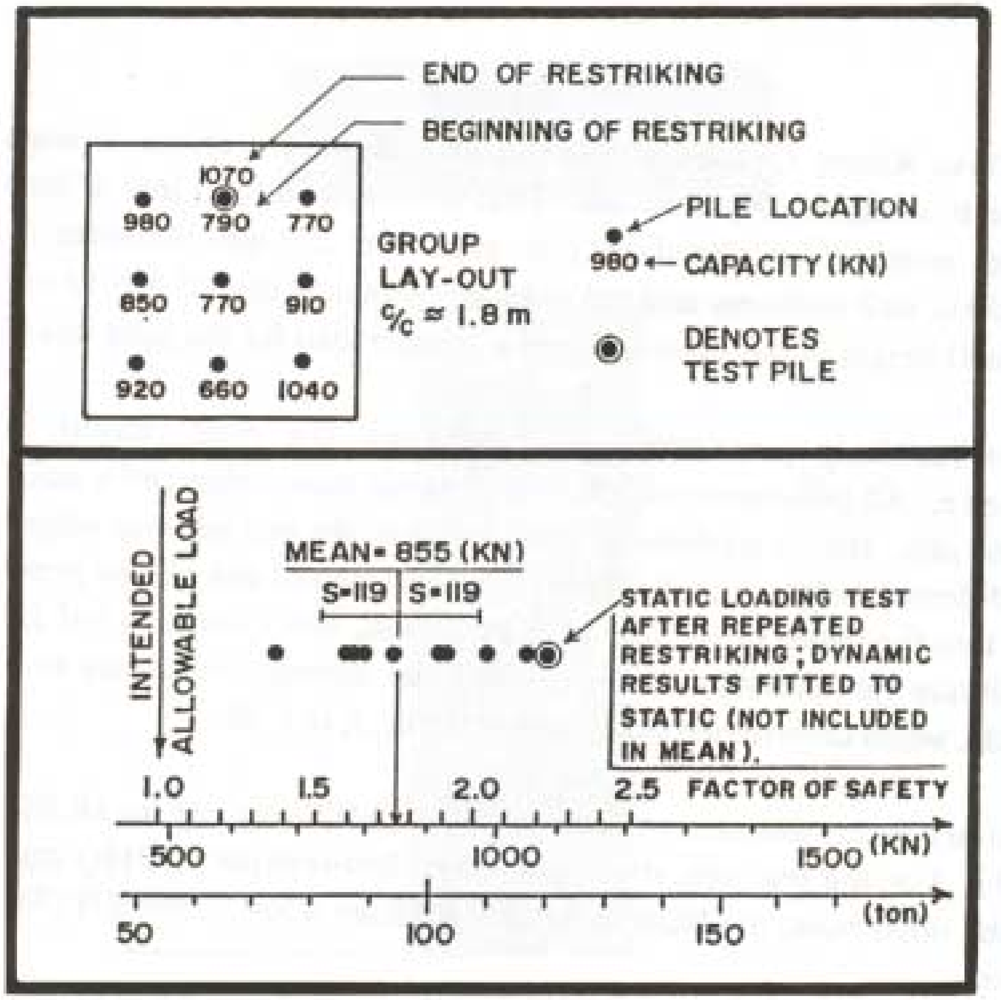

Fig. 2 Distribution of Capacity within the Pile Group

CONCLUSIONS

The two case histories demonstrate the delusion of believing that the behavior of the "representative pile" is identical to any other pile. When the safety factor is marginal, it may be wise to test several piles to determine a representative average capacity and its potential range. Further, when performing tests for the purpose of comparing methods, the same pile must be tested with the different methods, not separate piles, however similar one may assume the piles to be.

REFERENCE

FELLENIUS, B.H., SAMSON, L., THOMPSON D.E., and TROW, W., 1978. Dynamic behaviour of foundation piles and driving equipment. Terratech Ltd. and the Trow Group Limited, Final Report, Department of Supply and Services, Canada, Research Project, Contract No. 1ST77.00045, Vol. I and II, 580 p.