CHAPTER V

DISCUSSION

5.1 Modulus of Elasticity of Soil and Coefficient of Subgrade Reaction

The moduli of elasticity of soil are about 18.43 ksc. by Brom's approach and 104 ksc. by Poulos's approach. From load-deflection curves (Figs. 11 to Fig. 24), it is evident that the E_s = 104 ksc. gives the computed load-deflection curves closed to the observed curves.

The coefficient of subgrade reaction is related to the modulus of elasticity. The coefficients of subgrade reactions are shown in Table 5 and Table 6.

5.2 Load-Deflection Curves

The load-deflection curves for short piles are shown in Figs. 11 to 22, and Figs. 23 and 24 for long piles. The lateral deflections calculated from Brom's theory and Poulos's theory are compared with test data in Table 7 and Table 8. It should be noted that comparisons between the predicted load deflection curves and the observed curves, are shown in Figs. 11 to 24. Final deflections (measured values after 1 hr. or until the pile head movement was less than 0.01 in. per hr.) are considered in the comparisons.

(a) Short piles (pile Nos. 1 to 4)-Using a value of 18.43 ksc. for Young's modulus and the theory of subgrade reaction (Brom's approach) in the analysis, it can be seen from Table 7 that at a lateral load of 1631 kg. the calculated lateral deflections at the ground surface vary about 13.3 to 22.4 times the measured deflections, and the average of the ratio y_{calc}/y_{test} is about 16.5. It can be seen that the errors involved in the application of the theory of subgrade reaction to the solution of engineering problems have been very great according to the wide variation of the modulus of elasticity and the coefficient of subgrade reaction. Invalidation of the theoretical assumptions such as non elasticity and homogeneity of the soil, neglect of the skin friction effect along the pile, frequent creeping effect, magnitude and duration of test load are all factors producing errors. In the CRD test, the deflection is the initial deflection, and no time is allowed for deflection due to consolidation. Therefore the deflection obtained from CRD test is no good in predicting the true deflection of pile during its working life. The average of the ratio y_{calc}/y_{test} for CRD test is 7.1. In the Quick test only 5 minutes are allowed for deflection due to consolidation. The ratio y_{calc}/y_{test} for Quick test is 12.3 which is 25 % less than ML test. However, using a value of 18.43 ksc. for Young's modulus and the theory of elasticity (Poulos's approach) in the analysis, at a lateral load of 1631 kg. the calculated lateral deflections at the ground surface vary about 7.2 to 12.2 times the measured deflections, and the average of the ratio y_{calc}/y_{test} is about 8.9. It can be seen that the errors involved in the application of the theory of subgrade reaction are about 45 % higher than the application of theory of elasticity. The average of the ratio y_{calc}/y_{test} for CRD test is about 3.9, and 6.7 for Quick test.

In case of using a value of Young's modulus of 400 c_u (104 ksc.) and theory of subgrade reaction in the analysis, it can be seen from Table 8 that at a lateral load of 1631 kg. the calculated lateral deflections at the ground surface vary about 1.7 to 2.9 times the measured deflections, and the average of the ratio y_{calc}/y_{test} is about 2.1. The results have shown that the proposed theory of subgrade reaction gives a good prediction of the load deflection behaviour at working load, if a value of E_s of about 400 c_u is used. The average of the ratio y_{calc}/y_{test} for CRD and Quick test are about 0.9 and 1.6.

It should be noted that the piles Nos. 1 to 4 are classified as medium-length piles when a value of E_s of about 400 c_u is used because the βL is in the range $1.5 < \beta L < 2.5$.

Using a value of Young's modulus of 400 c_u and theory of elasticity in the analysis, at a lateral load of 1631 kg. the calculated lateral deflections at ground surface vary 1.7 to 2.9 times the measured deflections, and the average of the ratio y_{calc}/y_{test} is about 2.1. The results have shown that the subgrade reaction theory gives y_{calc}/y_{test} ratio nearly the same as the elastic theory. The average of the ratio y_{calc}/y_{test} for CRD and Quick test are about 0.9 and 1.6.

(b) Long piles (pile Nos. 5 and 6) - Using a value of about 18.43 ksc. for E_s in the analysis, it is found that at a lateral load of 750 kg. the calculated lateral deflections at the ground surface predicted by subgrade reaction theory are 4.6 and 3.7 times the measured deflections and the average value is about 4.2. For the elastic theory the ratio y_{calc}/y_{test} are 2.9 and 2.3 and the average ratio is about 2.6. It is found that the long piles give quite good predictions of the load-deflection behaviour, while the short piles give poor predictions. The main reason is that both theories neglect the effect of skin friction. The short pile is in rectangular cross-section but the long pile is in square cross-section. Therefore the effect of skin friction on the short pile is greater than that of long pile. Using a value of E_s of about 400 c_u in the analysis, at a lateral load of 750 kg. the calculated lateral deflections at the ground surface predicted by subgrade reaction theory are 1.5 and 1.2 times the measured deflections and the average value is about 1.4. For the elastic theory the ratio y_{calc}/y_{test} are 0.98 and 0.78 and the average ratio is 0.88.

5.3 Effect of Repeated Loading

The ratio of the deflection for the 30th cycle of 1631 kg. loading to that for the first cycle is 1.55 for pile No. 2 and 2.02 for pile No. 3.

5.4 Ultimate Lateral Resistance

(a) Short piles (Pile Nos. 1 to 4) - Comparisons between measured and predicted values of ultimate load P_{ult} are shown in Tables 9 to 12 with 10 failure criteria. It should be noted that criteria Nos. 1 to 8 are ultimate load criteria and Nos. 9 to 10 are deflection criteria. It is found that only criteria Nos. 1 and 10 give good agreement between the measured ultimate loads and those predicted from the theory. The criteria Nos. 6 to 8 deal with plastic deflection so they can be used to predict the ultimate load if only ML test with cyclic loading is performed. They are used with pile Nos. 2 and 3.

Using criteria No.1 and ML test in analysis, it is found that the measured ultimate loads vary from 0.79 to 1.13 times the calculated ultimate loads. The average of the ratio P_{test}/P_{calc} is about 0.93. For criteria No. 1, CRD test, the ratio P_{test}/P_{calc} is about 1.11, which is 18 % higher than ML test. For criteria No. 1, Quick test, the ratio P_{test}/P_{calc} is about 1.10, which is 17 % higher than ML test

Using criteria No. 10 and ML test in analysis, the measured ultimate loads vary from 0.96 to 1.08 times the calculated ultimate loads. The average of the ratio P_{test}/P_{calc} is about 1.01. For CRD test, the ratio P_{test}/P_{calc} is about 1.00, which is 1 % lower than ML test. For Quick test, the ratio P_{test}/P_{calc} is about 1.17, which is 16 % higher than ML test.

(b) Long piles (Pile Nos. 5 and 6) - Comparisons between measured and predicted values of ultimate load are shown in Table 13 with ten failure criteria. It is found that only criteria Nos. 1 and 9 give good agreement between the measured ultimate loads and those predicted from the theory.

For criteria No. 1, the measured ultimate loads are 1.31 times the calculated ultimate loads for pile No. 5 and 1.56 for pile No. 6. The average ratio of P_{test}/P_{calc} is about 1.44. For criteria No. 9, the measured ultimate loads are 1.30 times the calculated ultimate loads for pile No. 5 and 1.28 for pile No. 6. The average ratio P_{test}/P_{calc} is about 1.29. It is found that the observed cracking moments are 1.42 times the calculated cracking moments for pile No. 5 and 1.55 for pile No. 6.