Preliminary Study on Behavior of Model Raft & Piled Foundations in Soft Ground subjected to Road Embankment Loading

Saga University ○S.Mem. P. Poungchompu, S. Hayashi, Y.J. Du, D. Suetsugu, S.Mem. Y. Miyoshi

Introduction

This paper presents the experiments on performance of raft and pile system for improving soft Ariake clay ground subjected to road embankment loading. In the test, latex rubber membrane lined with grease was used to minimize sidewall friction. The deformations in the clay were monitored by deformed meshes plotted from frequent photo shots on latex rubber membrane. Totally, sixth cases are performed. Under the same loading conditions, the raft and pile system could reduce both the lateral deformations of the foundation and the settlement in the center of the embankment. Based on the test results, the effects of raft as well as pile length on reducing the settlement in the center of the embankment are discussed.

Test method

The conditions of the two model tests are summarized in Table 1. The test aims to evaluate the effects of the geometry of raft & pile elements. The model test set up attempts to simulate one-dimensional consolidation during clay deposition and plane strain condition during embankment loading.

Table 1 Profiles of test cases

Test case	Without Raft&Pile		With Raft		With Raft&Pile	
	Case MT-0f	Case MT-0s	Case MT-R1	Case MT-R2	Case MT-RP1	Case MT-RP2
Width of clay foundation(cm)	36	20	36	20	20	20
dimension of rafts(cm)	-	-	0.5*0.5	0.5*0.5	0.5*0.5	0.5*0.5
thickness of raft(cm)	-	-	0.5	0.5	0.5	0.5
spacing(cm)	-	-	-	-	-	-
Width of rafts(cm)	-	-	20	20	20	20
No. of layer raft	-	-	1	1	1	1
Dimension of piles(cm)	-	-	-	-	0.5*0.5	0.5*0.5
Spacing(cm)	-	-	-	-	0.5	0.5
Length of piles(cm)	-	-	-	-	8	11
Installed depth of piles(cm)	-	-	-	-	7	10
Tie rod method	-	-	-	-	top	top
Maximum Embankment loading(kPa)	10	15	30	30	30	30
Loading rate	fast test (10days)	slow test (6weeks)	fast test (10days)	slow test (6weeks)	fast test (10days)	fast test (10days)
Figure in text	Fig. 2(a)	Fig. 2(b)	Fig. 2(c)	Fig. 2(d)	Fig. 2(e)	Fig. 2(f)

Two clay bins with dimensions of 90cm in width, 20cm in length, and 30cm in height as shown in Fig. 1 are used in the model test. Latex rubber membrane and grease were used to minimize sidewall friction. The rubber membrane can be stretched and rolled to the desired position using a wooden bar. Remolded soft Ariake clay was used in this study. It was taken from 3 to 4 m depth in Kawazoe plain which has a very soft consistency and dark gray in color. Its physical properties are as follows; specific gravity: G_s=2.66, natural water content: w_n=110 %, liquid limit: w_L =87.5 %, and plasticity index: I_p=47.5. The preparation of clay specimen started in slurry condition, which was then poured into the clay bin until the initial thickness of 26 cm. It was then reconstituted under a 2.8 kPa pressure during one month under drained condition until it reached about 80% degree of consolidation. The vertical displacements at the clay surface during the loading stage were measured by dial gauges while the deformations within the clay were monitored by means of the deformed meshes plotted from frequent photo shots on latex rubber membrane that had been marked with grid points.

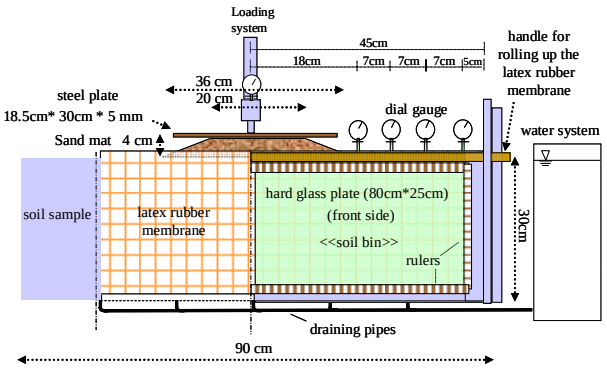

Fig. 1 Test apparatus

Results and Discussions

Considering the behavior of clay foundations due to embankment loads, deformation behaviors of the ground with and without any support are investigated to obtain the basic data for evaluating the effectiveness of the raft & pile methods. The vertical and lateral displacements of the ground are discussed. The test results of the displacements vector in the ground and the vertical displacement of embankment centre are shown in Fig. 2 and Fig. 3 respectively. It can be seen from Fig. 2 (a) and Fig. 2 (b) that the displacement of Ariake clay ground is similar to the failure of bearing capacity. The test also confirmed this fact. For casesMT-R1 and MT-R2, the raft is capable of reducing the vertical displacement due to embankment loading. For caseMT-RP1, caseMT-PR2, the raft-pile is capable of reducing both the horizontal and vertical have been reduced compared with the case MT-0f due to embankment loading. The settlements at embankment center are reduced remarkably for the caseMT-RP1 and caseMT-PR2 as shown in Fig. 3. The main effects of the raft-pile system implied that the stress conditions in the ground have been changed and thereby, both vertical and lateral displacements of the ground have been decreased. In order to discuss the effect of the pile length, two cases with the length L = 7 and 10cm are examined. The raft-pile system with tie rod is also tested as the method for controlling the deformation of the ground. Wire is used as the tie rod, and the connection of the cross tie rod at the pile top is set after installing the sheet-pile. The test result suggests that longer pile is more effective than shorter piles in reducing ground surface settlement at embankment centre as shown in Fig. 3. Compared with the case without raft-pile system, for the case with the raft-pile system both the vertical settlements in the centre of the embankment and lateral displacements in the ground are reduced.

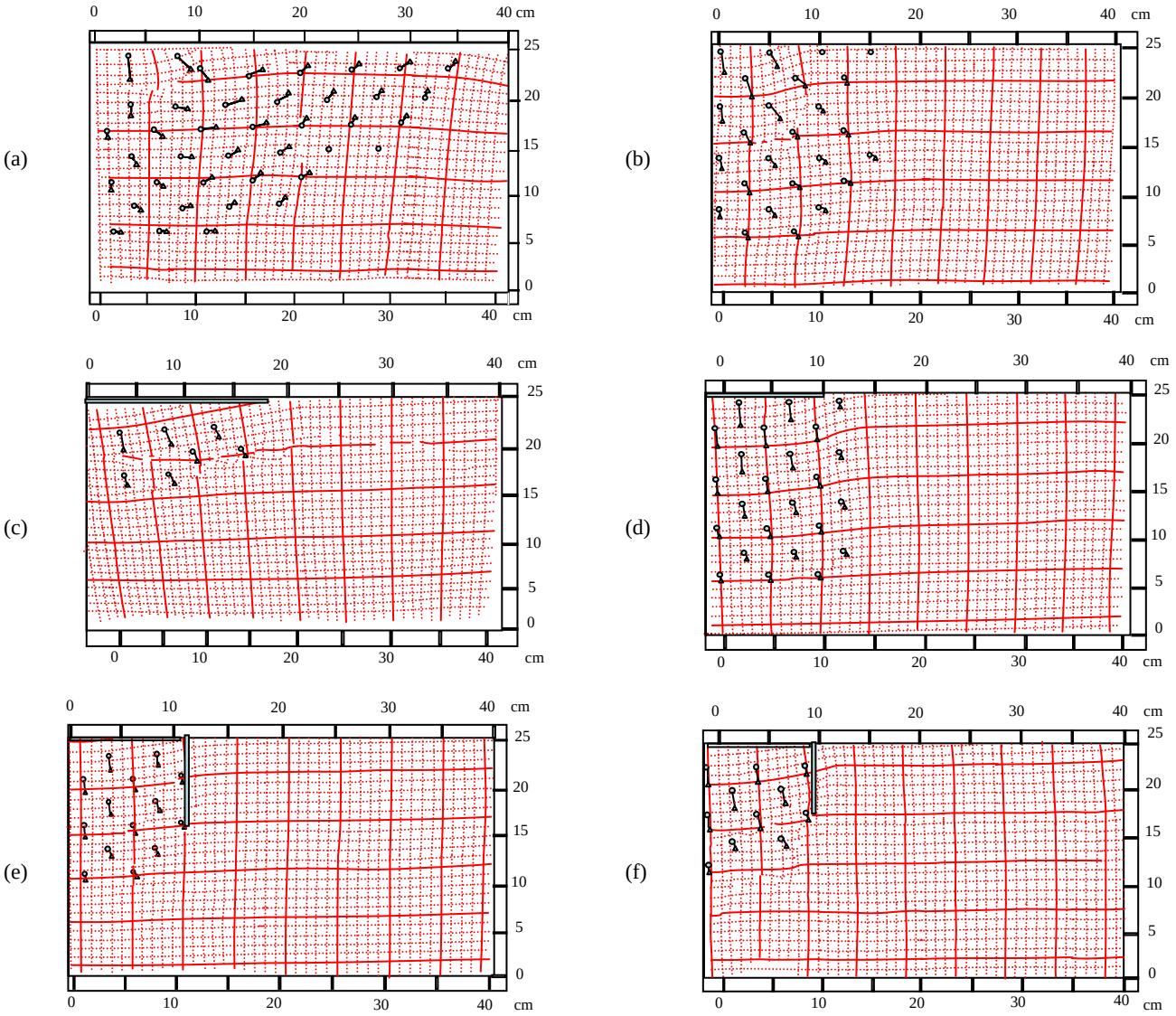

Fig. 2 Displacement vectors in ground (a) caseMT-0f collapsed under 10kPa (b) caseMT-0s collapsed under 15kPa (c) caseMT-R1 at the end of loading (30kPa, 10 days) (d) caseMT-R2 at the end of loading (30kPa, 6weeks) (e) MT-RP1 at the end of loading (30kPa,10 days) (f) caseMT-RP2 at the end of loading (30kPa, 10 days)

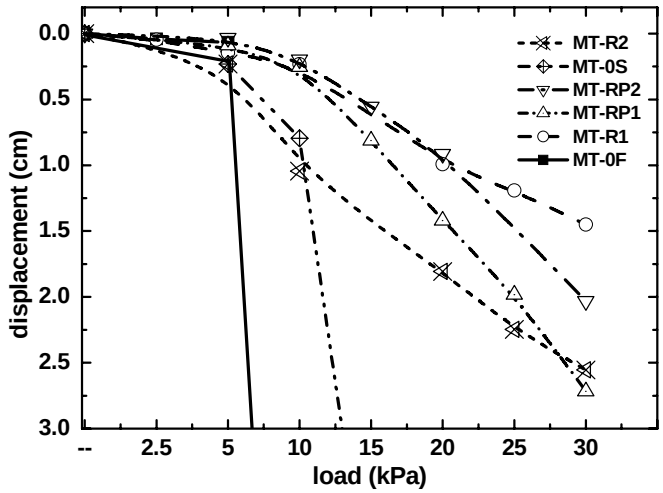

Fig. 3 Displacement at embankment surface in the centre

Conclusion

1. Test cases MT-0f and MT-0s (without raft foundation), loading without raft & pile system, large settlements and lateral deformations were observed.
2. Test case MT-R1 and MT-R2 (with raft foundation), both settlements and lateral deformations have been reduced compared to case without raft and pile system.
3. The raft & pile system used in the cases MT-RP1 and MT-RP2 with the pile length of 7, 10 cm, raft width of 20 cm and with tie rod on the top, decreased both the lateral displacement and settlement at embankment center remarkably
4. Longer pile is more effective than shorter piles in reducing ground surface settlement at embankment centre

References

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