# Laboratory Model Test on Raft & Pile System in Soft Ariake Clay

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## Introduction

The Raft & Pile method (Fig.1) is an economical ground improvement technique that has technical advantages derived from both raft and pile foundations. The raft carries the embankment loading by distributing it partly to the ground surface and partly to piles. The piles would then transfer the load to deeper and stronger soil layer. The lateral deformations and settlements are expected to be reduced significantly. In this study, a set of laboratory model test equipments were developed to evaluate the feasibility of using timber raft & pile method of ground improvement for road embankments constructed on soft Ariake clay. In this paper, only two tests corresponding to cases without raft & pile and with raft only (MT-0 and MT-1F, respectively) will be reported. The results indicated that, under the same loading conditions, the case with raft (MT-1F) could reduce the lateral deformations of the foundation and increase the bearing capacity effectively compared to the case without raft and pile (MT-0).

## Test method

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

Two clay bins having dimensions of 90cm wide, 20cm long, and 30cm high as shown in Fig.3 are used in the model test. Latex rubber membrane lined with grease was used to minimize sidewall friction. The rubber membrane can be stretched and rolled to the desired position using a wooden bar. A 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 until it reached about 80% degree of consolidation as shown in Fig.2. The first model test (Case MT-0) was done by applying loading in stages on top of the model embankment.Vertical and lateral displacements at the clay surface and within the clay are monitored during the tests(Ochiai, Hayashi, Umezaki and Otani, 1991). The vertical displacements at the clay surface 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.

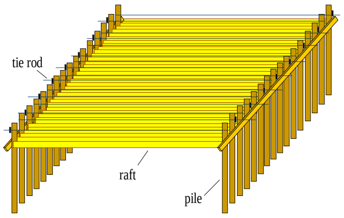


Fig.1 raft&pile model

Table1. test case

| Test case | Without Raft&Pile Method case MT-0 | With Raft&Pile Method case MT-1F |
|---|---|---|
| dimension of rafts(cm) | - | 0.5*0.5 |
| thickness of raft(cm) | - | 0.5 |
| spacing(cm) | - | - |
| Width of rafts(cm) | - | 36 |
| No. of layer raft | - | 1 |

## Results and Discussion

As indicated earlier, only two tests will be reported here. These test cases form the six cases that are planned in this study. Figure 4 shows the surface displacements of the model clay ground for the two cases. Increase settlements of loading plate according to this figure, the case MT-0 is more widely expanded ground at every settlement level of loading plate, while for case MT-1F is not much different at final stage of settlement. The displacement vectors in the model clay ground 124 hours after applying the 10 kPa loading are shown in Fig.5. Significant deformations in the ground are observed for the case without raft foundation.

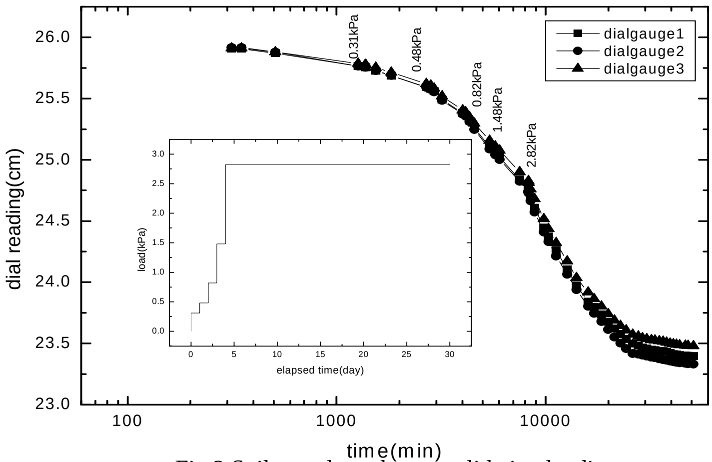


Fig.2 Soil sample under consolidation loading

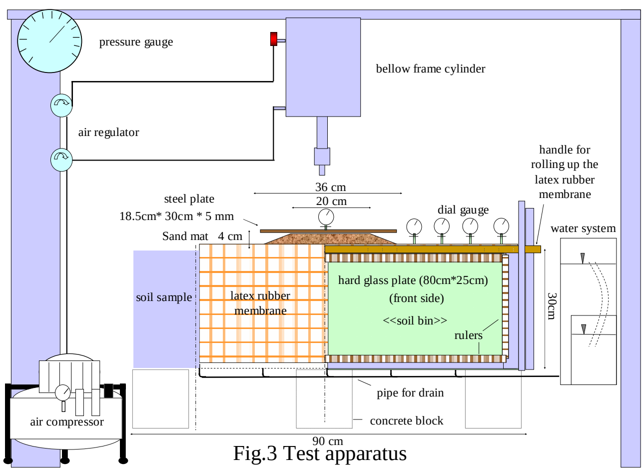


Fig.3 Test apparatus

Key words: raft&pile, consolidation, road embankment, deformation, soft clay foundation
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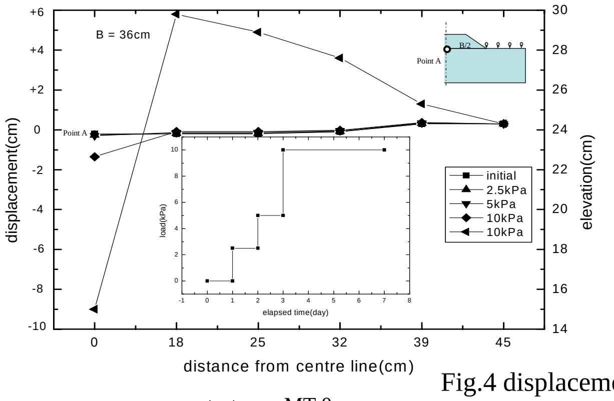
The corresponding deformed meshes based from photo shots of marked latex rubber membrane are shown in Fig. 6. This again demonstrates the effectiveness of raft foundation in reducing deformations. Further studies will be made consisting raft and pile foundations. It is expected that the piles can significantly alter the stress distributions in the clay ground and thus minimized further the deformations.



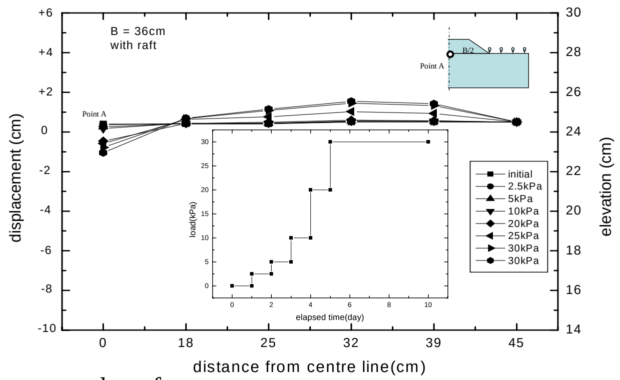
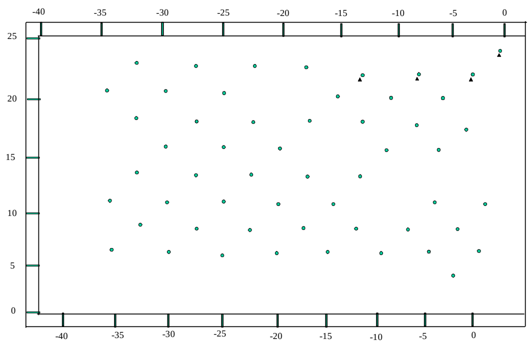
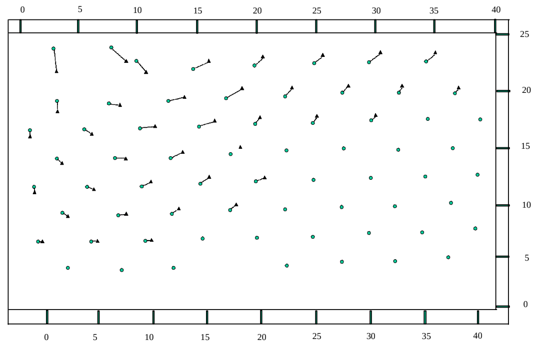




Fig.4 displacement on ground surface

test case MT-0 test case MT-1F

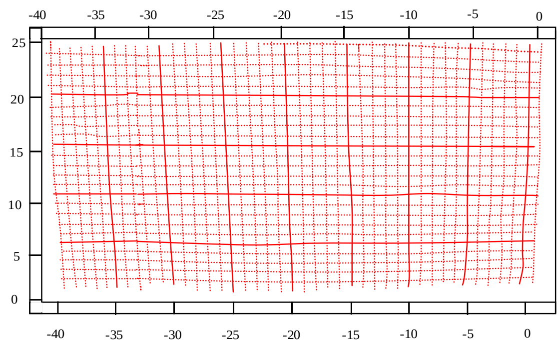


test case MT-1F

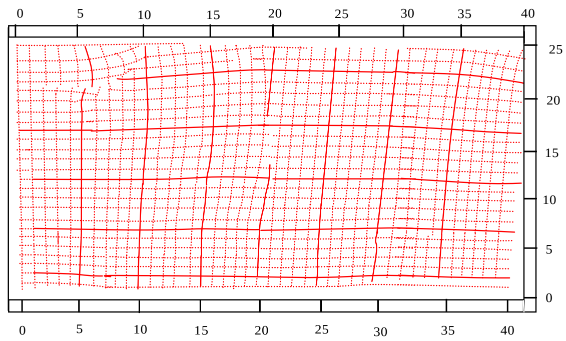


test case MT-0

Fig.5 displacement in ground after deformation (10kPa,124hr)



test case MT-1F



test case MT-0

Fig.6 displacement meshed after deformation(10 kPa,124 hr)

**Conclusion**

A series of model tests on raft & pile method for soft clay have been planned to be carried out. This will evaluate the performance of raft & pile method in improving soft Ariake clay under an embankment loading. So far, two tests have been done consisting embankment with and without raft foundation. The main conclusions that can be derived from these two model tests are as follows:

1. Test case MT-0 (without raft froundation), loading without raft&pile element, large settlements and lateral deformations were observed.
2. Test case MT-1F (with raft foundation), both settlements and lateral deformations have been reduced compared to case MT-0.

**References**

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