EXPERIMENTAL STUDY ON PILE COUNTERMEASURE FOR RETAINING WALL

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1. INTRODUCTION

The retaining wall has been constructed widely and required to be stable even in earthquake motion. It has been proposed that the deformation of the retaining wall could be reduced by the installation of piles nearby, not only in static condition but also in dynamic motion. However, there is not enough knowledge about the effectiveness of the installation piles in the different conditions of ground or dynamic motion. The retaining wall with short embedment would be unstable under an earthquake which occurs sand liquefaction. Therefore, the authors conducted a series of experimental tests in order to investigate the effectiveness of the installation piles against the deformation of the retaining wall changing the ground constitution and dynamic acceleration.

2.TEST CONDITION

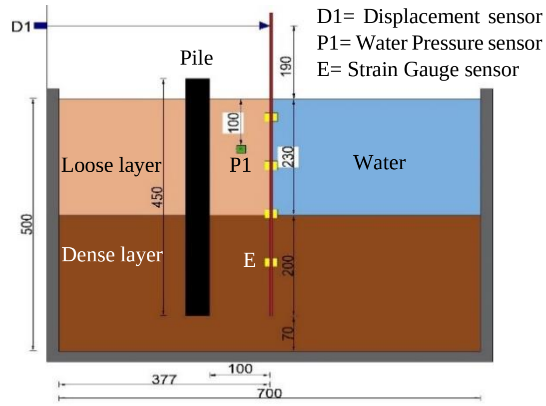
The model was geometrically scaled to approximately 1/20-1/30 of the actual structure, as shown in Fig.1. The rigid container consists of two layers; the bottom layer was filled and compacted as an unliquefiable layer. The soil for both layers was Toyoura sand (e_{max}= 0.927, e_{min}= 0.625, ρ_s= 2.64g/cm^3, k= 1.94×10^{-2} cm/s).

One half of the second layer was filled as a liquefiable layer and the other half with water. The liquefiable and unliquefiable layers relative density, thickness, and type of countermeasure shown in Table 1.

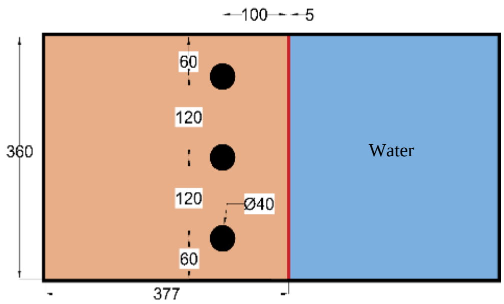
The experiments were conducted in two cases: Case-1 (unliquefiable layer with thickness of 270mm) Case-2 (unliquefiable layer with thickness of 350mm). In addition, the symbol of (a) means no countermeasure ,and the symbol of (b) means with a countermeasure. Three acryl pipes with 40mm diameter and 450mm length were installed in the landside, 100mm behind the retaining wall. An acryl plate with 5mm thickness as a retaining wall was located inside the unliquefiable layer, 70mm upper than the model box base. Three motions with intervals were given to the device for each case. The input motion was a sine wave of frequency 3Hz for 5 seconds. The maximum acceleration for each motion were 0.5, 1.0 and 2.0 m/s^2. The model test was equipped with three types of sensors, the displacement sensor connected on the top of the wall, 8 strain gauge sensors sticked on both sides of the wall , and one water pressure sensor located between wall and piles in the liquefiable layer.

Table.1 Test model layers specifications

Cases	Liquefiable Layer		Unliquefiable Layer		Countermeasure
	Dr(%)	Thickness (mm)	Dr(%)	Thickness (mm)	
Case1 (a)	42	230	94	270	No countermeasure
Case1 (b)	53	230	94	270	3 acryl piles
Case2 (a)	47	150	92	350	No countermeasure
Case2 (b)	48	150	92	350	3 acryl piles



(a) Cross section view



(b) Top view

Fig.1. Test model for Case 1(b) (Unit: mm)

3. RESULT AND DISCUSSION

The liquefaction caused the deformation of the quay wall toward the waterfront. Fig.2 shows the time histories of excess pore water pressure with initial effective stress for 0.5 up to 1 m/s^2 for Case 1(a). The excess pore water pressure presents the increment of pore water pressure from the initial value. Fig.3 shows the residual horizontal displacement at D1 (top of the retaining wall) for every motion in all cases. The acceleration of zero means before shaking, that means

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after making the test model. The displacement for Case 1(a) and (b) is more than that for Case 2(a) and (b). This is because the embedment of the retaining wall for Case 1 is shorter than that for Case 2. The displacement for Case 1(b) is less than Case 1(a) for before shaking (Static condition), and small motion (0 m/s^2 and 0.5 m/s^2). On the other hand, the displacement for greater motion (1 m/s^2 and 2 m/s^2) is almost the same for Case 1(a) and Case 1(b). This result indicates that pile countermeasure is more effective against low motion. The displacement for Case 2(b) in the static condition is a little less than Case 2(a) ;otherwise, for the dynamic condition is almost the same displacement. The effectiveness of pile countermeasure with long embedment is relatively smaller than that with short embedment. Fig. 4 shows the computed and measured distributions of residual bending strain along the retaining wall for Case 1 and 2. The result indicates that bending strain in Case 1(b) is less than Case 1(a) for the small motion (0 m/s^2 and 0.5 m/s^2) ;likewise, in the Case 2(b) for the small motion bending strain is less than Case 2(a). The result of bending strain matches to the result of the displacement, which means the pile countermeasure is more effective against weak motion and static condition. In Fig.4 (a) and (d), at 10mm, and 150mmhight strain gauges did not work.

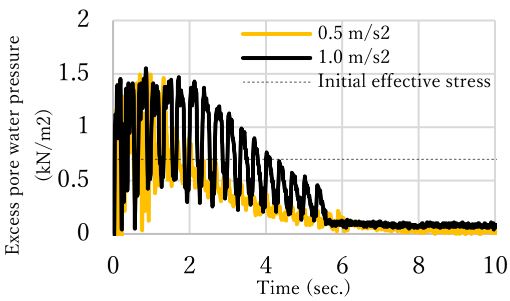


Fig.2. Time histories of excess pore water pressure

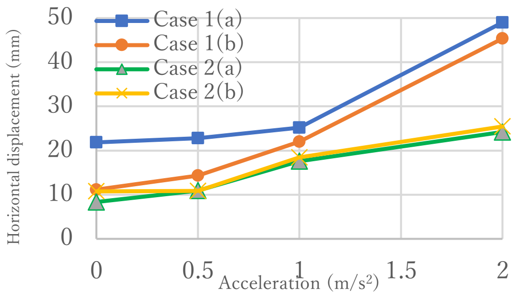
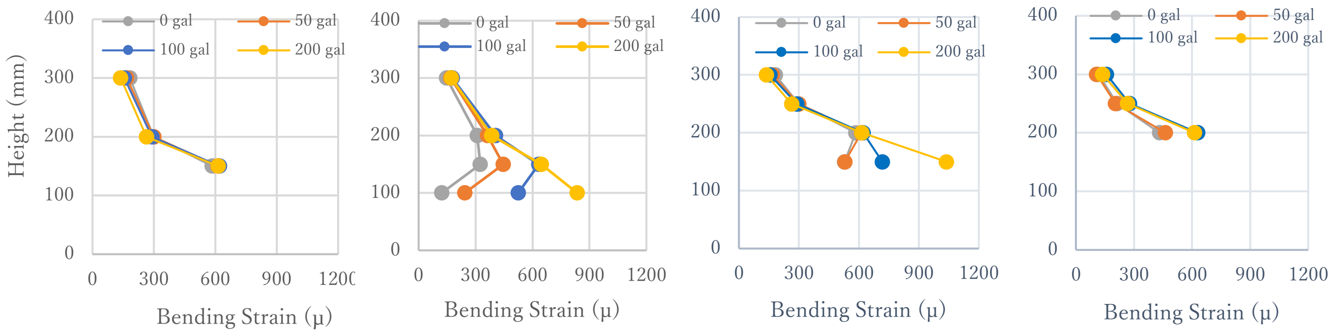


Fig.3. The residual horizontal displacement



(a) Case 1(a) (b) Case 1(b) (c) Case 2(a) (d) Case 2(b)

Fig.4. The residual bending strain along the retaining wall

4. CONCLUSION

The model tests on pile countermeasure behind a quay wall in two different thickness of unliquefiable layer was conducted, and the following conclusions were gained:

1) It was confirmed that the deformation of the retaining wall was reduced by the installation of the piles against small acceleration (0 m/s^2 and 0.5 m/s^2), from the results of the horizontal displacement and bending strains.

2) The more effectiveness of the piles could be gained for the short embedment of the retaining wall than long embedment.

3) The number of piles should be increased for the enhancement of this countermeasure against large earthquake which causes sand liquefaction.

5. REFERENCE

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