Investigating the function of basement for preventing liquefaction of sandy soil

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Introduction

Japan is the handful of earthquake-prone countries in the world. Liquefaction occurred in a wide range from Tohoku to Kanto in Tohoku-Pacific Ocean earthquake that occurred on March 11, 2011 in (Mw 9.0). As the result, thousands of houses and more than 15,000 people's life lost in the disaster. Many countermeasures of liquefaction have been developed and applied in the construction of large buildings. So in the earthquake, there was almost little damage to large buildings. On the other hand, due to the slow development of personal housing liquefied countermeasures, lead to more damage for these houses.

This study focusing on personal housing liquefied countermeasures, through experiments with the help of the basement, reducing liquefaction hazards and the improvement of the support are discussed, and evaluate the rigid continuous basement model.

Testing

Focusing on small and medium-sized civil residence, this study will evaluate the function of basement in preventing liquefaction of sandy ground. By comparing with different structure forms in vibratory testing, the inhibitory action of liquefaction will be discussed in this study.

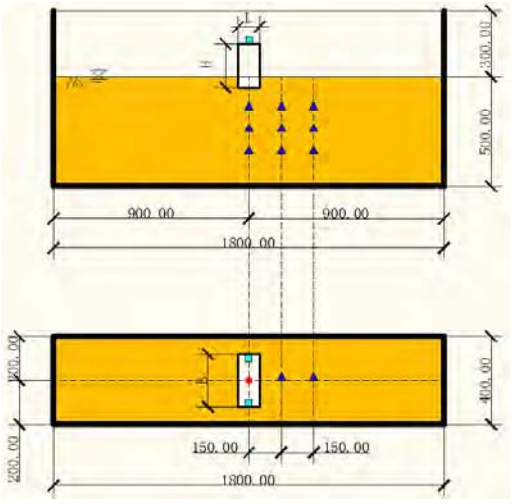


Figure 1 Schematic illustration of model testing (unit: mm)

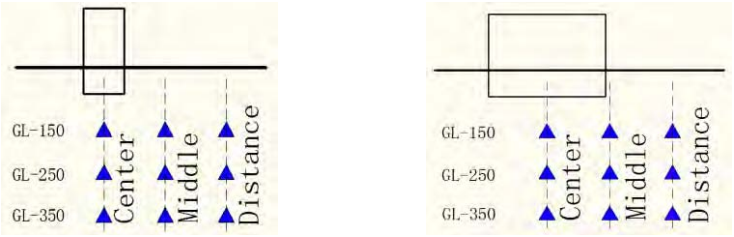


Figure 2 Test conditions

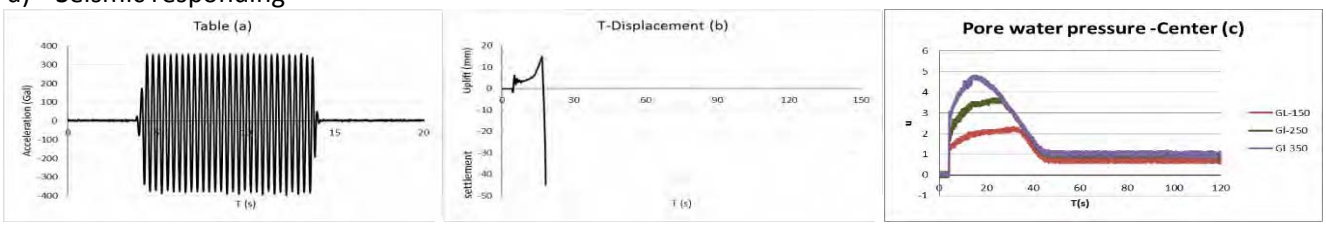
Table 1 The details of Model conditions

	Items	Testing Model	Real object
Case 1	Size	L100mm*B240mm*H160mm	L5m*B12m*H8m
	Depth of basement	50mm	2.5m
	Weight	18.0 N	
	Buoyant force	11.8 N	
Case 2	Size	L280mm*B240mm*H160mm	L14m*B12m*H8m
	Depth of basement	50mm	2.5m
	Weight	35.2 N	
	Buoyant force	35.2 N	

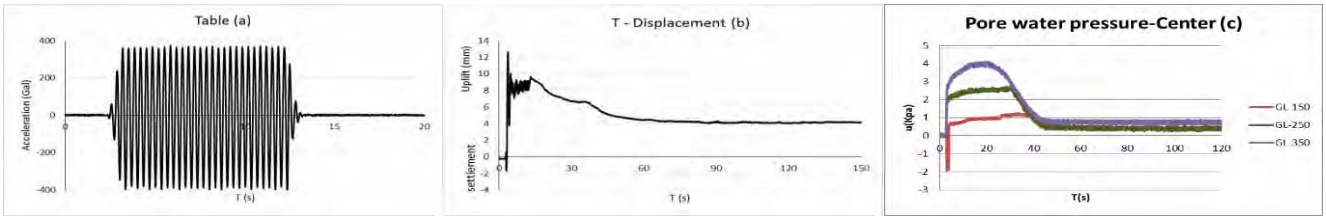
The conditions of Case 1 (single house) and Case2 (three continuous house) are showed in the Fig.2, moreover, the details are listed in the Table 1. By water falling method, the ground which is made of Toyoura sand can achieve the nearly full saturation. Adjust the height of the sandy ground in the box (length 1500mm, breadth 400mm, height 800mm) up to 500mm, meanwhile, the relative density (Dr) get to around 30%. The seismic wave was input in sinusoidal with frequency f = 3 Hz, and make the maximum acceleration reach 400 Gal in 10s for testing. As showed in Fig.2 the pore water gauges were set by different depths, divided to three groups, and the Center Group was focused on for next discussion.

Results

a) Seismic responding



Case 1



Case 2

Figure 3 The responding

The record read from the acceleration gauge which is set on the vibration table shows actual situation of the whole testing case. At the same time, because of the larger buoyant force of Case 2, the greater uplifting occurred when the liquefaction began in this fully saturated ground. On the contrary, the model in Case 1 turned over finally in the testing, which shows the higher stability in Case 2. Relative to Case 1, Case 2 shows a lower pore water pressure referred to Fig. 3.

b) Maximum Excess PWP ratio

The magnitude of pore water pressure (excess PWP ratio) is used to estimate the extent of the liquefaction, which is defined as:

$$\text{Max excess PWP ratio} = \frac{u'}{\sigma'_z}$$

σ'_z is the effective stress; u' represents the modified pore water pressure. Because of the dropping down of the gauges during the shaking, the pressure is greater than the magnitude in original location (set at zero), as the result, the curve of PWP can't return back to T-Axis (Fig. 3c). Using the original PWP (u) to minus Δu by the method showed in Fig. 4, the maximum modified PWP u' is achieved finally.

The pore water pressure rose sharply from the shaking starting until reaching the pink point, after that, it is falling slowly by time, and returned to peace (Fig. 3). Almost all points is larger than 1.0 (Fig. 5), therefore, complete liquefaction can be predicted in both Case 1 and Case 2. Comparing with Case 1, all points in Case 2 show lower excess PWP ratio less than 1.5 and closed to 1.0.

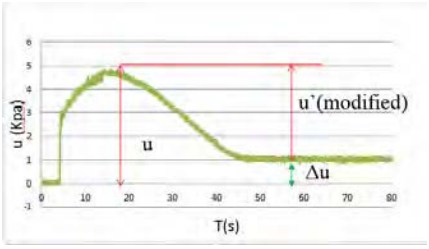


Figure 4 Method of modification

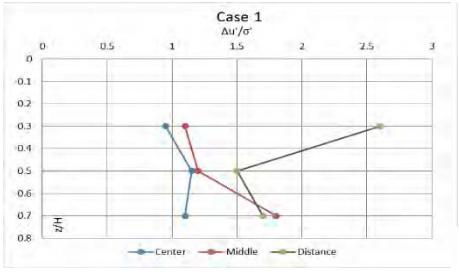


Figure 5 Max excess PWP ratio

Conclusions

a) Three continuous house with basement showed higher stability than single house on the view of settlement and inclination of house.

b) The greater basements can restrict to the excess PWP ratio, result in weakening the liquefaction problem in earthquakes.

References

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2) Yoshiaki Yoshimi, *Simplified design of structures buried in liquefiable soil*, Soil and foundations Vol. 38, No. 1, 235-240, Mar. 1998.