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Study on the ground characteristics of irregularly distributed ground through centrifuge tests

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ABSTRACT

Centrifuge tests were performed to study on the ground characteristics of irregularly distributed ground. The bedrock was simulated using concrete and the comparison was performed according to the presence or absence of the bedrock. The accelerations at different depth and locations were measured to estimate the site characteristics. The results showed that the period of site with inclined bedrock was shorter than the site only with soil. Also, the response spectrum shifted due to the difference of site period.

1. INTRODUCTION

Various earthquakes in the past inflicted large amount of damage due to the site amplification effect. This phenomenon occurred during Mexico City earthquake in 1957 and 1985, Northridge earthquake in 1994, Kobe earthquake in 1995, and Pohang earthquake in 2017. Particularly, in Pohang earthquake (2017), severe damages were occurred although peak ground accelerations of Pohang earthquake were smaller than those of Gyeongju earthquake (occurred in 2016 near Pohang earthquake). The amplification of the mid-period component was largely caused by the Pohang site characteristics, which had a great influence on the behavior of the near-surface structure.

In the present study, the centrifuge tests were performed for different bedrock shape. The site characteristic results were compared including site period and response spectrum.

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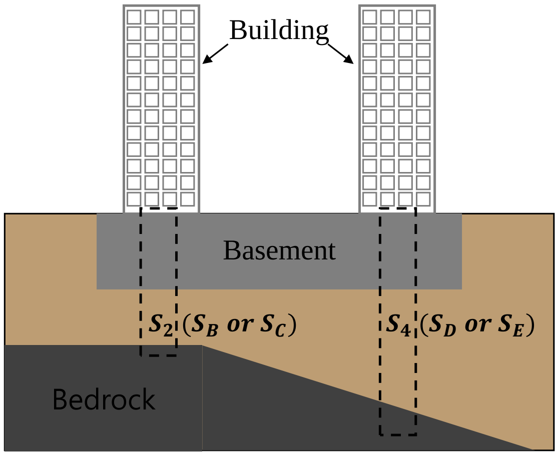

Fig. 1 Site with irregularly distributed bedrock

2. Test plan

2.1 Centrifuge test

The centrifuge test is and experiment to simulate the confining pressure of soil which influences the dynamic behavior of the soil. The actual site condition can be simulated with 1/N scale model through centrifugal acceleration of N gc (fc : centrifugal acceleration). In order to simulate the infinite boundary condition, an equivalent shear beam (ESB) model container, which could reduce reflection of waves at the boundary, was used.

2.2 Material properties

Experimental specimens consist of ESB model container, soil, and concrete for simulating the bedrock. The test with ESB model container fully filled with soil is designated as test S0 which means the sloe of bedrock is 0° (Fig. 2(a)). To simulate the inclined bedrock, 45° of concrete was used (S45, Fig. 2(b)). The equivalent shear wave velocity of concrete can be estimated by modulus of elasticity. From the concrete compression test, the modulus of elasticity of concrete was measured as 69.44 GPa and the equivalent shear wave velocity was 3200 m/s.

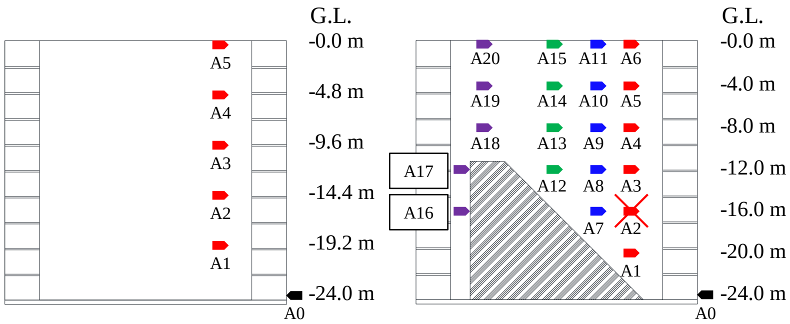

Fig. 2 Test specimens: (a) S0; (b) S45

2.3 Measurement

Test results were measured from accelerometers located as shown in Figure 2. An accelerometer (A0) was located at the bottom of the ESB model container to measure the bedrock motion. In the test S0, 5 accelerometers (A1 ~ A5) were arranged at equal distance of 120 mm. In the test S45, accelerometers (A1 ~ A20) were arranged at 100 mm intervals vertically and at the same height horizontally. Some accelerometers (A16, A17 in S45) were attached to the concrete to see the movement of concrete. A2 in S45 was not accurately measured and were excluded from the analysis.

3. Test results

3.1 Response spectrum

Figure 3 shows the ratio of response spectrum (RRS) which is normalized response spectrums at surface with bedrock response spectrum. RRS shows the amplification characteristics of the soil. The peak RRS value occurred at the site period. The site fundamental periods of S0 and S45 were 0.53 s and 0.40 s, respectively.

3.2 Site period

Figure 4 shows the site periods according to bedrock PGA estimated from ratio of response spectrum. Increasing the PGA causes a larger strain in the soil, and the soil stiffness decreases due to the nonlinearity of the soil. Therefore, the site period tended to increases as the PGA increases. As shown in Figure 4, site period of S0 is longer than model with inclined bedrock (S45).

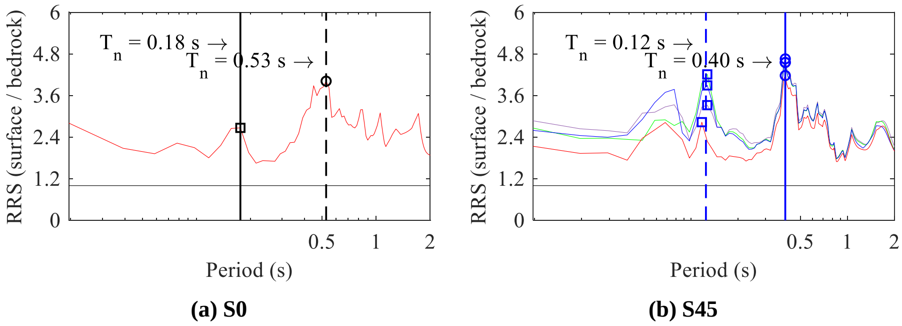

Fig. 3 Ratio of response spectrum: (a) S0; (b) S45

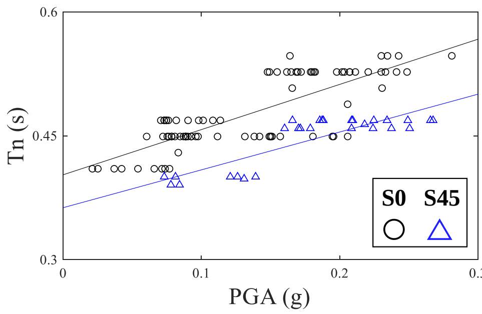

Fig. 4 Site periods according to bedrock PGA estimated from RRS

3. CONCLUSIONS

Centrifuge tests were performed to study on the site characteristics of irregularly distributed bedrock. One model consists of full soil (S0) and model with inclined bedrock (concrete) were compared.

When comparing the site period according to the input PGA, the site period increased as the input PGA increased. This is because that the soil becomes soft, and the stiffness decreases as the input PGA increases. The periods of S45 were smaller than the period of S0 due to the presence of bedrock which has larger weight and bigger stiffness than soil.

REFERENCES

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