A ROLE OF SURFACE GROUND IRREGURALITIES IN EARTHQUAKE HAZARD EVALUATION

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INTRODUCTION

It is essential to know the condition of the ground when evaluating earthquake hazard. It is well known that the surface soil condition and micro topography influence the seismic intensity of the ground and hence impact structural damage to the buildings and civil infrastructure during earthquakes. The objective of this study is to examine dynamic characteristics of an irregular ground by looking into a slope located at the edge of a terrace, which is a common landform in and near the Tokyo metropolitan area, based on microtremor and seismic motion observations as well as multi-dimensional finite element analyses.

OBSERVATIONS AND MEASUREMENTS

Target Area - Throughout this study, Chiba city is selected as a target area. Chiba is located at about 40 km east of Tokyo. Figure 1 shows landform classification in central Chiba and also shows the locations of microtremor and seismic motion measurements. The landforms of this area consists of terrace, lowland and reclaimed ground. Terrace is covered with a volcanic cohesive soil, under which there is a heap of diluvial sands. Lowland is normally covered with soft alluvial soils. It is noted that there exists a fairy steep slope between terrace and lowland.

Microtremor Measurements - Microtremor measurements were carried out at six sites. H/V spectra show a lot of variations when measured in the sites located near a slope at the edge of a terrace. For example, Fig. 2 shows a relationship between the distance from a slope at the edge of a terrace and predominant frequencies of H/V spectra at site B. It is found that the predominant frequencies change to higher values in accordance with the distance from the shoulder of a slope in the case of a natural slope like site B. This is due to the existence of a weakened soil along the slope. Fig. 3 shows a cross sectional view of the ground of this site, constructed from a variety of soil investigation results.

Seismic Motion Observations - Seismic motions were observed at 3 locations; at the foot of a slope (S1), at the shoulder of the slope (S2) and in the middle of a terrace (S3). From Fourier spectral ratios between the two sites, it can be pointed out that S2 gives higher spectral intensities in the frequency range of 2 to 6 Hz, while S3 gives lower spectral intensities in the same frequency range, when compared to other locations. S1 is the lowest for higher frequencies above 6 Hz. S2 is the highest for all frequencies.

EFFECT OF A SLOPE ON THE DYNAMIC PROPERTIES OF THE GROUND

Analysis Model - In order to examine the effect of the existence of a slope, two-dimensional finite element analyses of a simple uniform soil model with a slope have been carried out first.

Effect of Height - From the analysis, it was found that the frequency dependency of the amplification function changes according to the distance from the slope but the overall characteristics do not change that much regardless of the height of the slope. The peak value itself, however, increases as the height increases. The affected area due to the slope becomes large when the height is large. It is worthy of note that amplification is suppressed along the slope and at its foot.

Effect of Inclination - The effect of inclination of a slope on the dynamic characteristics of the ground is not clear. However, it is noted that, larger the inclination, larger the amplitude at the shoulder of the slope. The affected area due to the slope is limited to the terrace and in the vicinity of the shoulder of the slope.

Effect of Weakened Soil along a Slope - In the case where there exists a weakened soil along a slope, the two-dimensional analysis gives higher natural frequencies and higher amplifications at the shoulder when compared with the one-dimensional analysis and that its frequency dependency is much more complicated. It was also found that the influence of the existence of a slope is small compared to the effect of a weakened soil, but its area of influence is far more broad.

EFFECT OF A WEAKENED SOIL ON THE FAILURE RISK DURING EARTHQUAKES

Two-dimensional elasto-plastic finite element analyses have been carried out. The analysis model has dashpots at the boundaries and the Rayleigh damping was assumed as material damping. As a constitutive relation, the so-called modified Ramberg-Osgood model was used. The analysis model is similar to the one used in the previous analysis except that the viscous boundary was assumed at the both sides of the model in addition to the bottom boundary.

From the analysis, it can be pointed out that, due to a weakened soil, accelerations along a slope, especially in the vertical direction, become large and that the shape of the slope (height and angle) does not have a significant influence on accelerations along the slope, except in the case of a large height in which accelerations become large inside the weakened soil. It is also possible to point out that without weakened soils along a slope, no significant concentration of large shear strains is observed in the ground. However, there is a case in that a circular pattern of fairly large shear strains appears near the slope, indicating the possibility of a circular failure of the ground at the slope. In the case of a slope with a weakened soil, very large strains are developed throughout the weakened soil, meaning that there is a high possibility of slope failure occurring in this part of the slope.

CONCLUSIONS

In this study, the dynamic characteristics of the ground near a slope located at the edge of a diluvial terrace have been examined in detail. Based on the results, it was found that there are cases where the effect of ground irregularities are significant when considering the behavior of the ground during earthquakes.

REFERENCES

S. Nakai, Y. Nagata and T. Sekiguchi: Effect of a slope on the dynamic properties of diluvial terrace, Proc. 5th Int. Conf. Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, Paper No. 4.40b, 2010

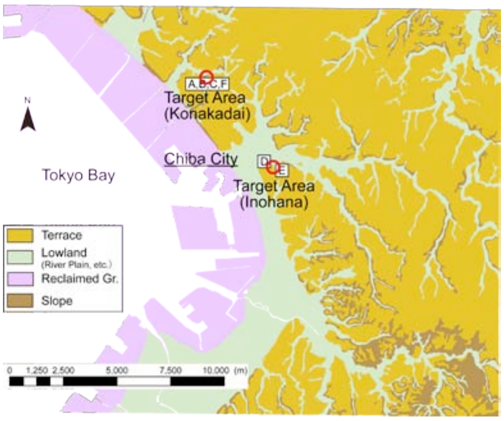

Fig. 1 Target area (Chiba city)

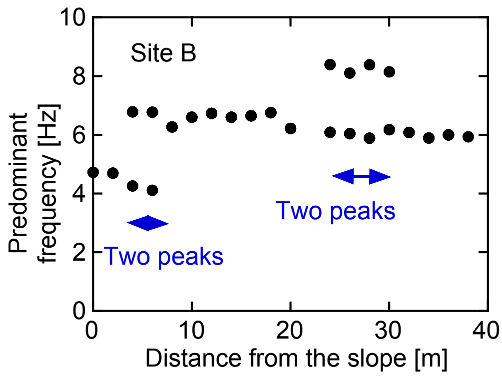

Fig. 2 Variation of predominant frequency

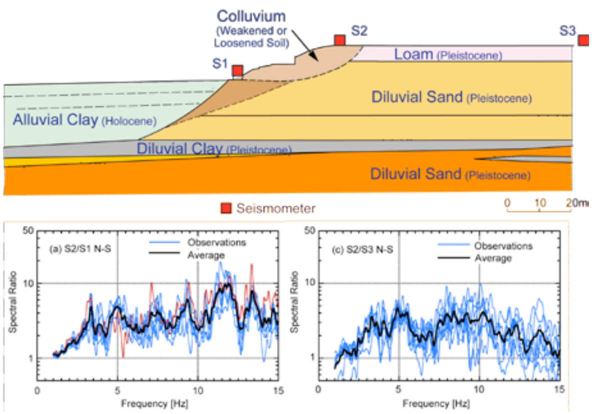

Fig. 3 Soil profile and Fourier spectral ratios

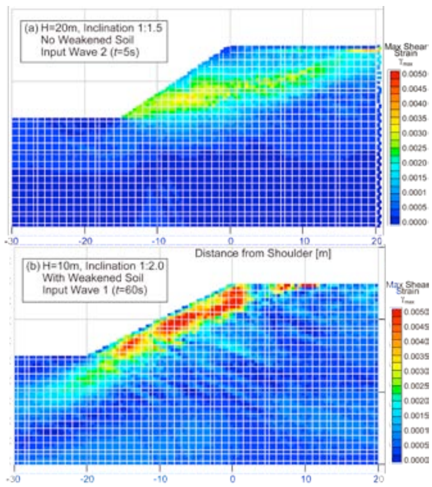

Fig. 4 Shear strain during an earthquake