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NUMERICAL ANALYSIS OF SEISMIC GROUND MOTION PROPAGATED IN IRREGULAR SOIL BOUNDARY CONDITIONS

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ABSTRACT

This paper describes the influence of the irregularities in geological conditions on seismic ground motion. For this, as preliminary study, the seismic response for the soft sediment media over the sloping bedrock is pre-examined by two-dimensional (2-D) finite element method. From 2-D analysis it is found that the seismic characteristics may not the influenced by the effects of the sloping enough away from the sloping in the region enough away from the sloping part of bedrock. Then the ground motion recorded at the site enough away from the sloping part of bedrock is simulated numerically using one-dimensional (1-D) approach by SHAKE. The results of this simulation gives a good agreement with the recorded motion.

KEYWORD

seismic ground motion, soft sediment media, sloping bedrock, response spectrum, finite element method

INTRODUCTION

In general, ground motion recorded on the surface in greatly affected by the geographical features and kind of surface layer in the vicinity of an observation point, thus the influence of the irregularities in near surface soil-layer on the seismic ground motion is a major matter of concern.

Attention is focused on Zushi-city in Kanagawa pref., and the present paper considers the ground models with soft sediment media over the sloping bedrock. As preliminary study the seismic response is analyzed by 2-D finite element approach. From the viewpoint of computational effort, 1-D approach may be advantageous over 2-D counterpart due to its simplicity and user efforts. The results are compared to those obtained by 1-D analysis, and it is found that the results of 1-D analysis provide a good agreement with those of 2-D approach in the region far enough away from the sloping part of the bedrock. Then the recorded surface ground motion at Zushi-city is simulated numerically by applying 1-D approach.

RESPONSE CHARACTERISTICS OF GROUND WITH SLOPING BEDROCK

Analytical models

Two types configuration of bedrock are considered as illustrated in Fig. 1 and analyzed by 2-D finite element approach leading to the complex response method. For Model A bedrock forms the sloping at both sides while Model B has an single side sloping of bedrock.

A bring parametric study is undertaken to develop an insight into the effect of the sloping by varying the key parameters, *viz,* α, a slope angle, V_S, shear velocity, and H, the thickness of the soft sediment layer, as shown in Table 1. The velocity of shear wave in bedrock is assumed to be 700 m/sec.

The material properties are determined based on the observed sites in Zushi-city. The seismic response is obtained by 1-D analysis for the layered model so as to examine the response characteristics of motion on the ground surface.

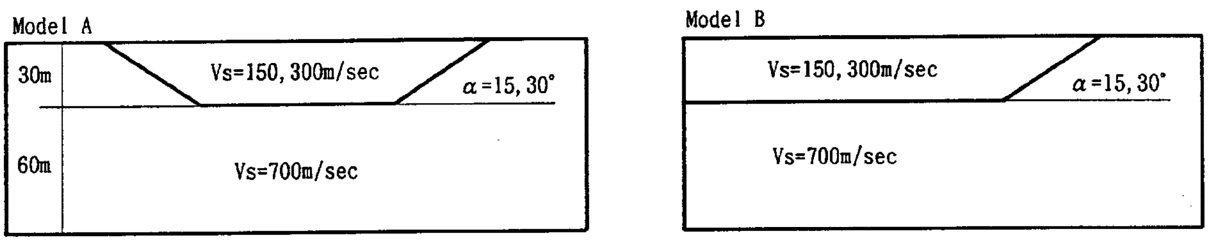

FIg.1 2-D ground models

Table 1 Material properties for analysis (see Fig.1 as key)

	Density (t/m^3)	S-wave Velocity (m/sec^2)	Poisson's ratio	Damping Factor h	Angle α (deg.)	Depth H (m)
case-1A					15	30
case-1B	1.4	150	0.40	0.05	30	
case-3A					15	10
case-2A	1.7	300	0.35	0.05	15	30
case-2B					30	

The TAFT(1952) EW component is applied and input at the bottom of the bedrock, providing that the maximum acceleration is set to 100 Gal. The computer codes Super FLUSH for 2-D analysis and SHAKE for 1-D analysis are employed in the present study.

Discussion

Fig. 2 plots the ratios of the acceleration maxima by 2-D analysis to 1-D counterpart along the ground surface. It is observed that 2-D analysis gives small values in comparison to 1-D approach within the sloping part of the bedrock. In contrast, the ratios become lager than unity and almost constant along the flat portion of the bedrock. From the figures it could be said that the acceleration response is influenced by the sloping in the range of twice the length of Ls from the point P. It is noted that solution from those obtained by Model B and 1-D analysis, particularly in the centered part of the models. Such discrepancies are currently under the subject of investigation.

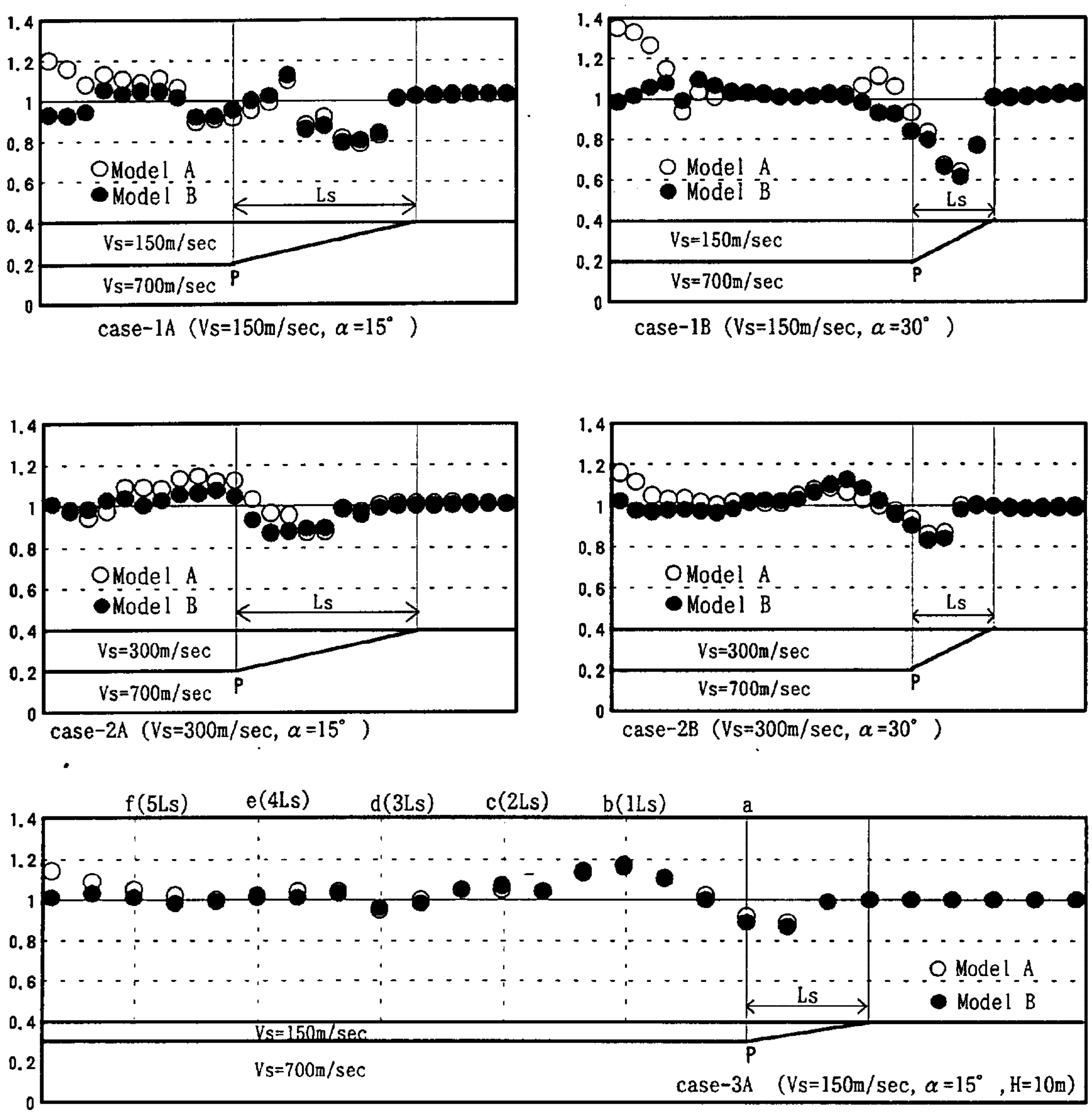

Fig.2 Ratios of the acceleration maxima by 2-D analysis to 1D

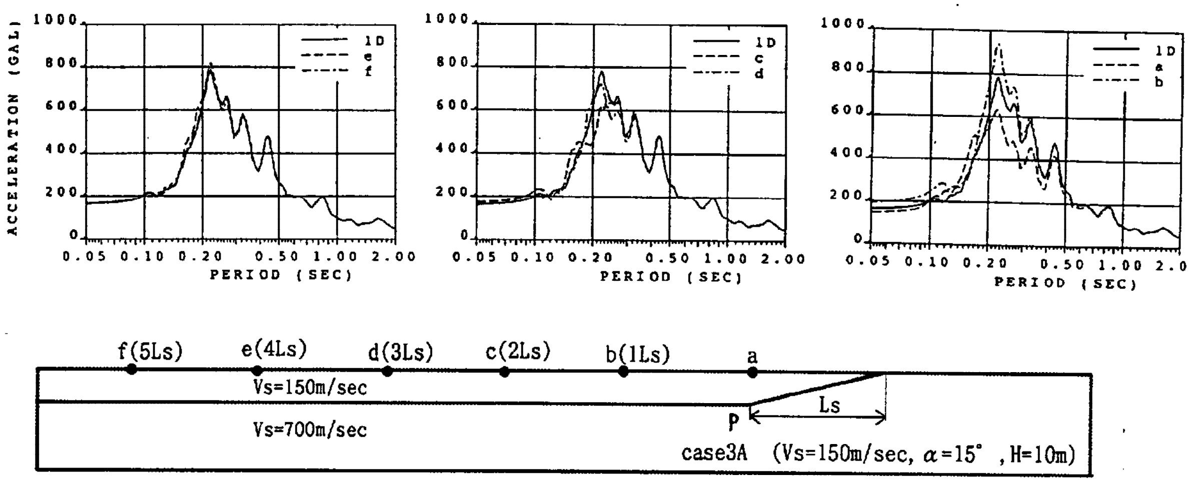

Fig.3 Acceleration response spectra at ground surface for Model B

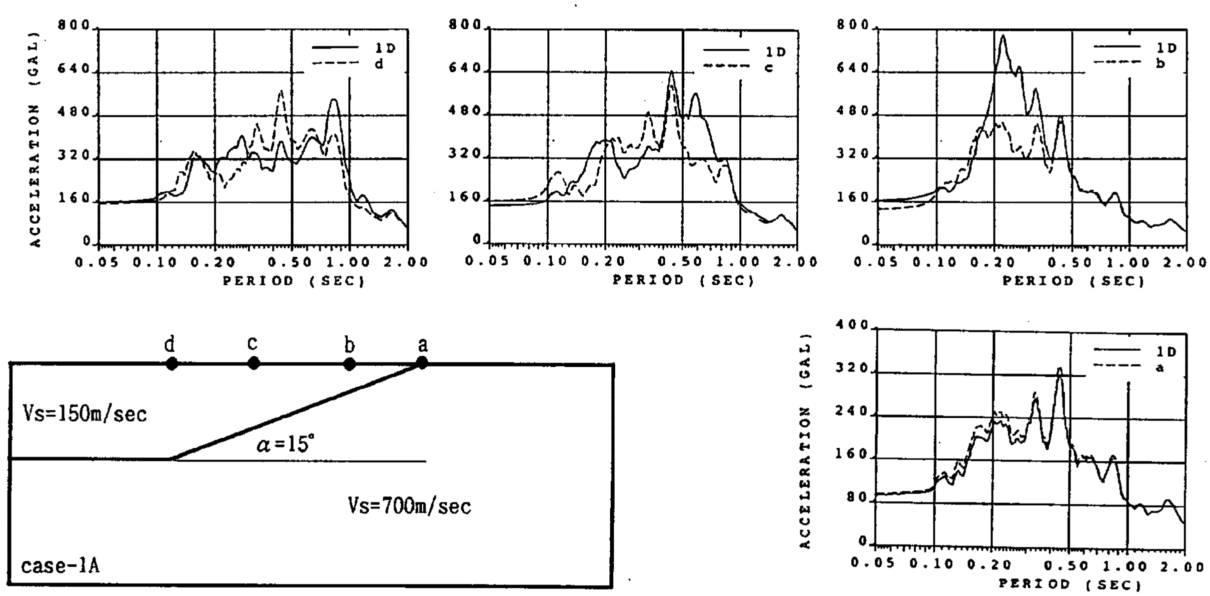

Fig.4 Acceleration response spectra at ground surface for Model B

For Model B, Figs. 3 and 4 present comparisons of the acceleration spectra between 2-D and 1-D analysis. The differences in frequency characteristics are observed in the sloping portion of the bedrock; however, the discrepancies vanish along the flat area of the bedrock. Also, the variation of amplitude in 1-D analysis tends to provide a sufficient approximation to 2-D analysis in the region enough away from the sloping.

As long as the present study is concern, the frequency characteristics of response spectra of both 1-D and 2-D approaches are in phase for the range where the distance from the point P is at least three times of the length of L_S.

SIMULATION OF EARTHQUAKE OBSERVATION RECORD

General

For the purpose of the regional disaster prevention plan of Zushi-city, seismometers are placed at five sites with different soil properties and have been kept in monitoring since June, 1994. Simulation for the observed record is carried out based on the discussion in the preceding section. Zushi-city is located in the root of the Miura peninsula; Fig. 5 presents the map of the Zushi-city. Hills are located in the south and north areas and Sagami bay is in the west. There is Tagoshi river across over the city from the east to west so that the valley forms soft alluvium lowland.

We selected two earthquakes, No. 1 and No. 2, to simulate the seismic response. The No. 1 and No. 2 were observed on July 3, 1995 and January 1, 1995 respectively; the epicenter of the former is Salami bay (M5.6) while the later is located at Tokyo bay (M4.1). Table 2 shows the physical properties of two observed records.

The simulation is carried out under the condition that the incident wave is taken as the observed record picked up at the bedrock (SYK), and motion of the ground surface at four observation sites (see Fig.5 as key) is calculated. It is noted that the input wave for SYK is assumed to be common to the four sites. The nearest observation site from the SYK is at Zushi elementary school (ZSS); the distance between the SYK and ZSS is about 1.5km and the thickness of the sediment soil layer in the vicinity of ZSS is 30m. The bedrock makes the form of the sloping near SYK, but the soil-rock interface is relatively flat under the observation sites. It must be borne in mind in the preceding discussion, if an observation point is enough away from the sloping of the bedrock, the adequate accuracy is attainable by 1-D approach to predict the seismic response. The dynamic material properties are shown in Table 3 (a–d).

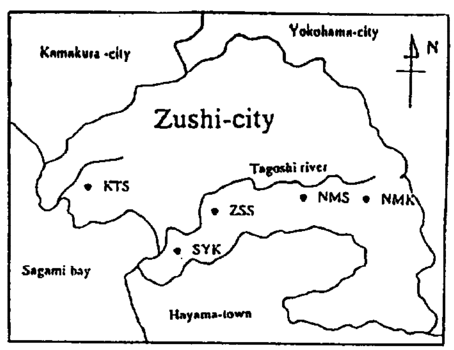

Fig.5 Sites location

Table 2 Description of earthquake of No.1 and No.2

	Date	Focal region	Latitude	Longitude	Depth	M
No.1	95/01/01 5:52:26	TOKYO Bay	35° 37'	140° 06'	76km	4.8
No.2	95/07/03 8:53:23	SAGAMI Bay	35° 09'	139° 34'	122km	5.6

Table 3(a) Dynamic material properties at ZSS

Depth Range (m)	Density (t/m^3)	S-wave Velocity (m/sec^2)	Damping Factor h
0.0 - 1.0	1.4	100	0.05
1.0 - 4.0	1.7	150	0.05
4.0 - 14.0	1.8	180	0.03
14.0 - 28.0	1.8	200	0.03
28.0 -	2.1	700	0.02

Table 3(b) Dynamic material properties at KTS

Depth Range (m)	Density (t/m^3)	S-wave Velocity (m/sec^2)	Damping Factor h
0.0 - 2.0	1.7	150	0.05
2.0 - 7.0	1.4	100	0.05
7.0 - 13.0	1.8	200	0.03
13.0 -	2.1	700	0.02

Table 3(c) Dynamic material properties at NMS

Depth Range (m)	Density (t/m^3)	S-wave Velocity (m/sec^2)	Damping Factor h
0.0 - 1.0	1.7	150	0.05
1.0 - 6.0	1.5	120	0.05
6.0 - 12.0	1.7	150	0.05
12.0 -	2.1	700	0.02

Table 3(d) Dynamic material properties at NMK

Depth Range (m)	Density (t/m^3)	S-wave Velocity (m/sec^2)	Damping Factor h
0.0 - 6.5	1.7	150	0.05
6.5 - 8.5	1.8	200	0.03
8.5 -	2.1	700	0.02

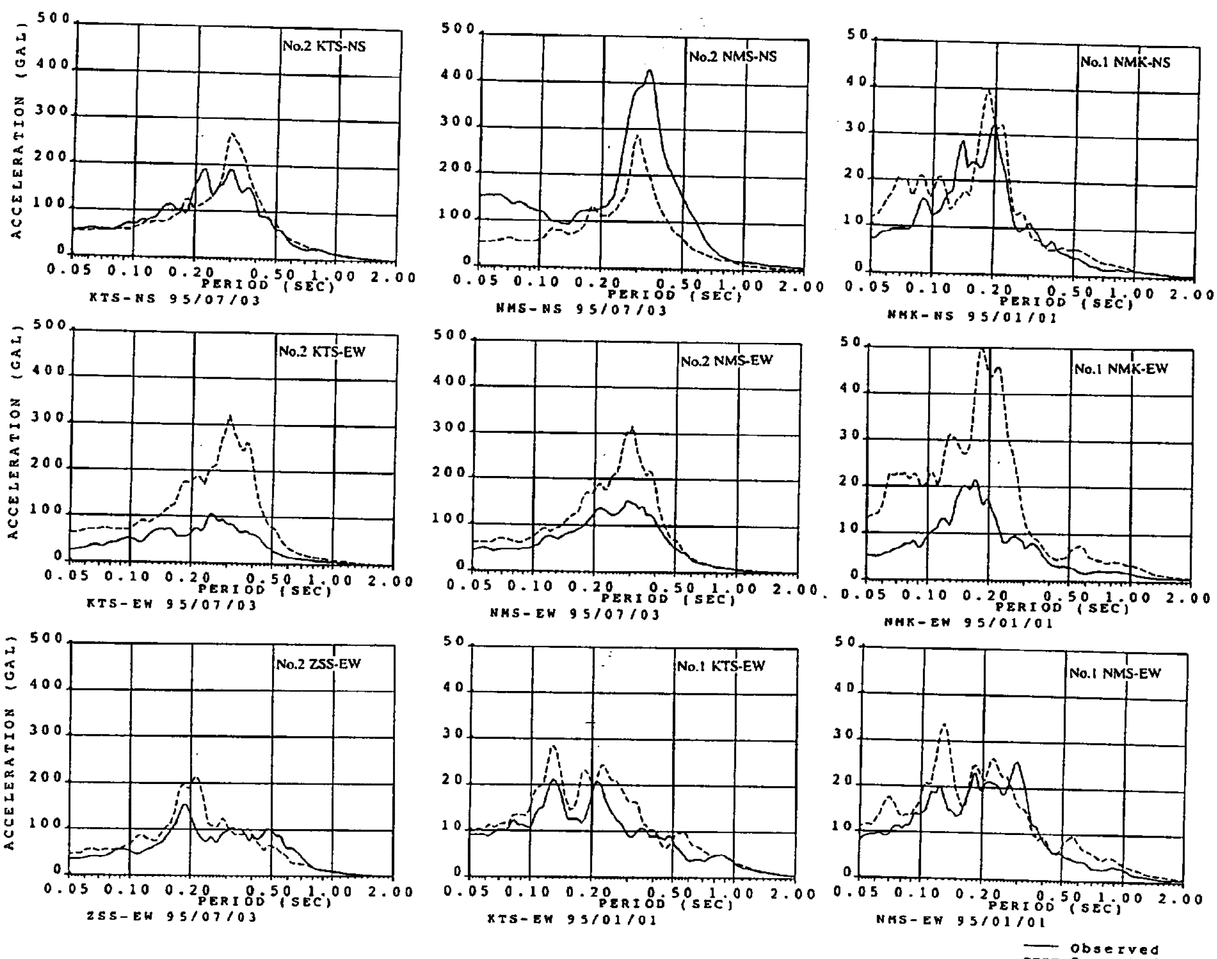

Fig.6 Comparisons of acceleration response spectra

Discussion

Fig. 6 compares the acceleration response spectra obtained by the simulation with those of observed records. In comparison to the simulated results and observed records, the response spectra in EW component of earthquake No.1 at NMK and the same component of the No. 2 at both KTS and NMS gives considerable different profiles; the simulated results provide larger values than the observed ones. Turning out our attention to the frequency characteristics, the simulated results are relatively well suited to the prediction of the observed records.

CONCLUSIONS

The influence of the irregularities in the ground condition on the seismic ground motion of the surface is investigated. To deal with this problem, we consider the models for which the seismic response for soft sediment media over sloping bedrock is examined by 2-D finite element approach. As a result, in case of one side sloping bedrock, the effects of the sloping is influenced to the twice the length of the horizontal projection of the sloping portion. Some numerical study implemented 1-D approach by SHAKE is performed to simulate the observed records in Zushi-city. The numerical simulation has demonstrated the relative ease with which the reasonable accuracy of the surface ground motion may be evaluated with a high degree of accuracy providing that it assumes appropriate incident wave at the bedrock and considers the irregularities of the geological conditions in the vicinity of an observation point.

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