SEISMIC WAVE PROPAGATION AND AMPLIFICATION BY THE SHEAR ZONE DURING THE 2001 GEIYO EARTHQUAKE

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1. INTRODUCTION

The seismic wave amplification for a deep soil deposit model during the 2001 Geiyo earthquake has been investigated. The special attention has been given to shear zone effect in the deep soil model. The large displacements have been observed in the near-fault region after the earthquake. The geological investigations[1)] have indicated a shear zone with 30 km depth along the Yunoyama Fault surrounded by stiff media as shown in Figure 1. It is considered that the shear zone having weak soil properties had also important effects on the large deformations on ground surface. The shear zone and surrounding stiff media have been modeled by Finite Elements and half-space has been modeled by Boundary Elements. The deconvoluted observed earthquake motion of Kure station motion has been used as the input motion in the analysis. The surface ground motion responses have been evaluated.

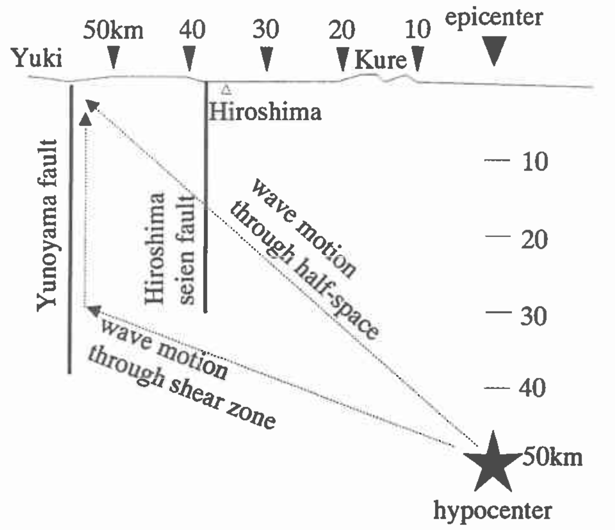

Figure 1: Shear zone model for Yunoyama Fault during 2001 Geiyo Earthquake[1)]

2. EARTHQUAKE CHARACTERISTICS AND OBSERVED GROUND MOTIONS

The earthquake occurred on March 24, 2001 with a magnitude 6.4 in JMA scale. The epicenter was offshore in Hiroshima Bay, and hypocenter depth was 50 km depth in Seto Inland Sea. The earthquake occurred on subducting slab of the Philippine Sea Plate. The intensity was lower 6 on the Japanese scale of 7 in near epicenter area. The ground motions in the broad range of area has been recorded by (K-net)[2)] and (KIK-net)[3)]. The peak ground acceleration was 651gal in Mihara station (HRS017) with 49 km epicentral distance. In this study the Kure station (HRS019) record, which is the nearest station record to epicenter has been concentrated for the analysis.

3. THE INPUT MOTION FOR THE ANALYSIS

The Kure station horizontal -EW- component acceleration record, and its Fourier transform are shown in Figure 2(a). The soil profile for the station can be found in K-net home page[2)]. In the view of the soil properties in the station, the recorded motion has been deconvoluted to obtain bedrock motion. The equivalent-linear approach has been utilized for the deconvolution. The deconvoluted motion acceleration and displacement records, and their Fourier Transforms are presented in Figure 2(b) and 2(c), respectively. The deconvoluted displacement record has been taken as the input motion and considered at 11km depth as vertical wave incidence with horizontal component motion.

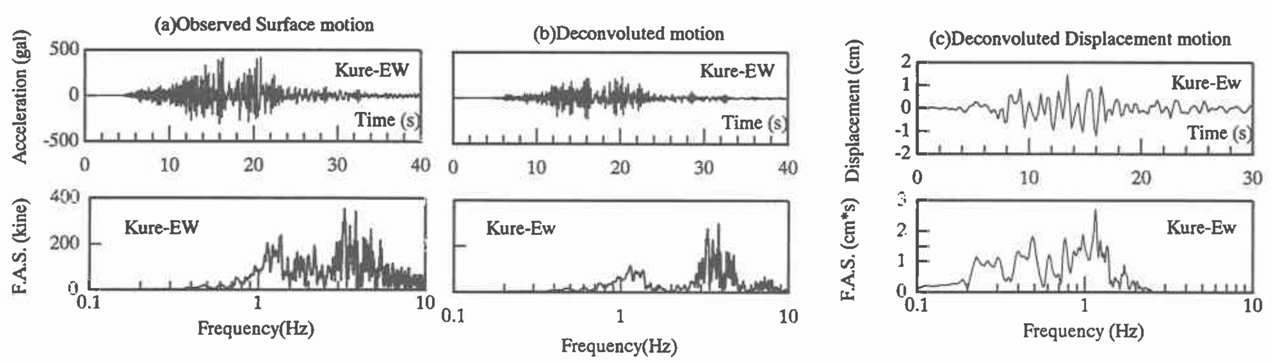

Figure 2: (a) Observed surface ground motion acceleration at Kure Station for -EW- component, (b)Deconvoluted acceleration motion at the bedrock, (c) Deconvoluted displacement motion at the bedrock

3. THE MODEL AND ANALYSIS

The computer simulation has been conducted by employing the two-dimensional time domain FE-BE hybrid technique[4)]. The weak shear zone region and surrounding stiff rock soil media have been modeled by finite elements, and outer half-space is modeled by the compatible boundary elements. The Figure 3 shows the FE-BE model for the computer simulation. The dimensions of the model are assumed as shown in

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the figure to simplify the model for the computation easiness. The material properties for the model are presented in Table 1. Different damping ratios have been assigned within shear zone for the finite element region to investigate the effect of the damping ratios on the surface response. Totally, 2929 nodes and 2800 elements have been used in the finite element region, out of them 226 nodes have been used as the interface nodes and 27 nodes have been used as the surface nodes. The boundary element discretization has been performed along the interface for representation of the half space. Totally, 244 nodes have been used in the boundary element region, including 226 interface nodes and 18 free surface nodes both side of the model. The time step is set to 0.2s in BE region and 0.1s in FE region. Point-1 and Point-2 have been defined in the model for the detail investigation subsequently.

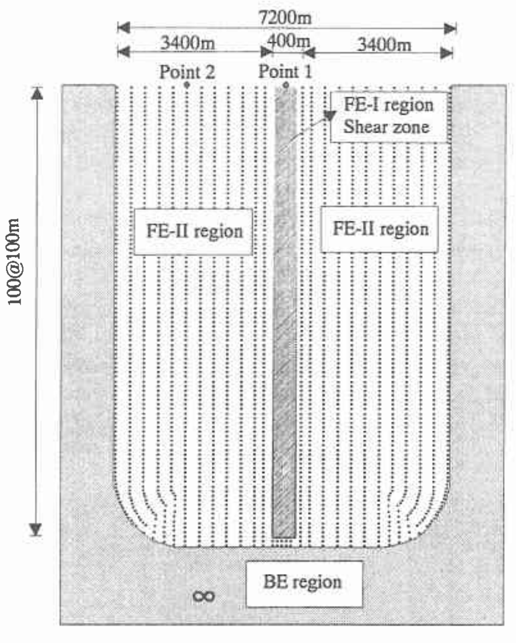

Figure 3: FE-BE model for computer simulation

Table 1: Material properties for the analysis model

Region	S Wave Velocity (m/s.)	Poisson Ratio ν	Density ρ ($x10\ t/m^3$)	Damping (%)		
				Case A	Case B	Case C
FE I	500		1.35	0	2	5
FE II	2300	0.35	1.95	0	0	0
BE	2300		1.95	0	0	0

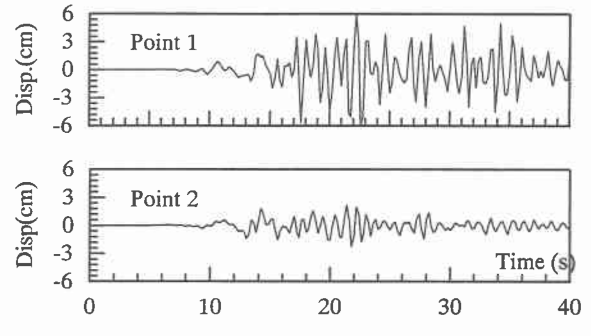

Figure 4: Ground surface displacement-time history on Point 1 and 2.

4. ANALYSIS RESULTS

The ground surface displacement-time histories in Point-1 and Point-2 have been presented in Figure 4. The high amplitudes can be seen in Point-1, which is located on top of the shear zone. In Point-2, lower amplitudes can be observed. Although one main peak can be seen in Point-2 displacement history around 22s, in Point-1 two main peaks can be observed around 22s and 34s. Only one peak in Point-2 represents the wave propagation through stiff rock media, and two peaks in Point-1 indicate that the first peak occurs because of the wave propagation through stiff rock media, and the second peak because of the wave propagation through shear zone. The maximum horizontal and vertical displacement responses on the ground surface are depicted in Figure 5 and Figure 6, respectively. High amplifications can be seen on top of the shear zone. Different damping factors in Case A, B and C point out how amplification increases by decreasing damping factor.

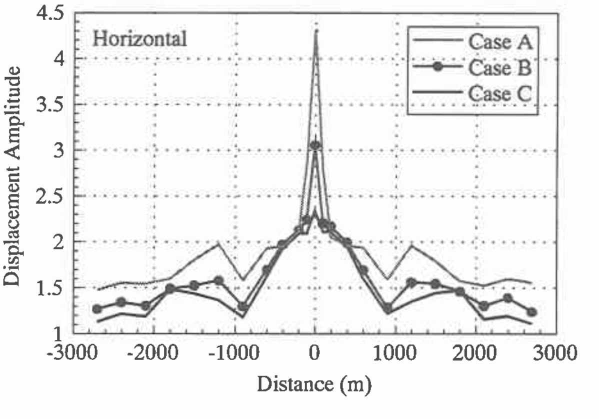

Figure 5: Horizontal motion surface displacement response amplitude

4. CONCLUSION

The seismic wave propagation and amplification during the 2001 Geiyo Earthquake has been studied by paying attention to shear zone effect. The analysis results point out that presence of a shear zone will increase the possibility of high deformations on ground surface and in structures subsequently. The structures, which will be built in and around shear zone region, should resist large deformations by taking into consideration the possible amplification due to shear zone effect.

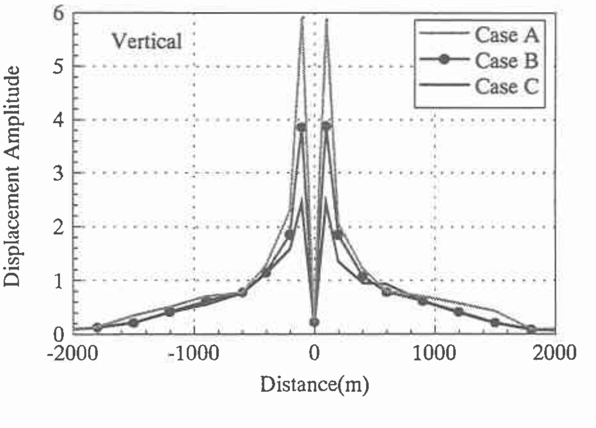

Figure 6: Vertical motion surface displacement response amplitude

5. REFERENCES

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