STRONG GROUND MOTION SIMULATION FOR OKAYAMA CITY DUE TO A POSSIBLE NANKAI TROUGH EARTHQUAKE

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1. INTRODUCTION

In this study, it is objected to estimate strong ground motions in Okayama City due to the fault rupturing during a possible future scenario earthquake in Nankai trough. The ground motions are simulated with a hybrid method by combining deterministic and statistical approaches. The combination has been accomplished through the wavelet analysis technique. It is purposed to estimate ground motions with wide frequency range for more realistic simulation.

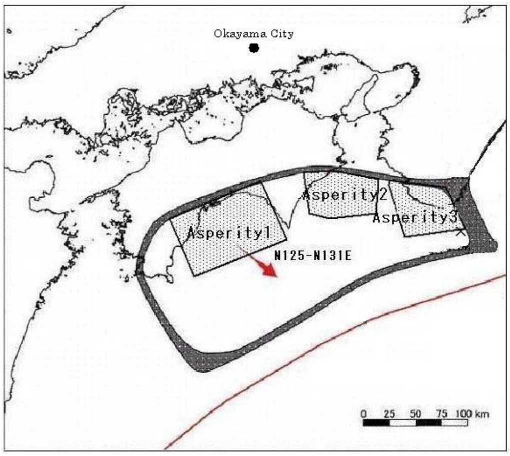

Figure 1. The location of the scenario earthquake and active faults[2]

2. TECTONICS AND SEISMIC PARAMETERS

The investigations[1] indicate that earthquake occurrences in western Japan are dense along the Nankai trough because of the complex tectonic structure zone. The Philippine Sea plate is slipping and subducting beneath the Eurasian plate at an average speed of 4 to 5 cm/year and generates ruptures that results in large magnitude earthquakes. After the 1995 Hyogo-ken Nanbu, 2000 Tottori-ken Seibu and 2001 Geiyo Earthquakes in the western Japan the researches on the possible future earthquake in Nankai trough have been focusing. The investigations[2] on the historical earthquakes in the Nankai trough indicate that the possible future earthquake will be 8.4 in magnitude. The location of the scenario earthquake and active faults are shown in Figure 1. In this study, it is objected to estimate possible strong ground motions in Okayama City during the future possible Nankai Trough Earthquake. The target location for the ground motion simulation has been chosen at the K-net Okayama station[3] as marked in Figure 1, which is located 295km from the presumed epicenter. Three asperities have been considered in the model. The seismic parameters from the Headquarters for Earthquake Research Promotion[2] used as follows: Total fault length is 300km, and fault width is 150km. The fault strike angle is ϕ = N65°E, and dip angle is δ=7.66°. The hypocenter depth is 15 km. Fault rupture velocity is V_r=2.7km/s and the shear wave velocity is V_s=3.8km/s.

3. SIMULATON METHOD

The simulation of ground motions is targeted in a broadband frequency range from 0.1Hz to 12.5Hz. This has been achieved with a hybrid simulation method, which is the combination of deterministic approach for low frequencies from 0.1Hz to 1.56 Hz, and statistical approach for high frequencies from 1.56Hz to 12.5Hz. This combination is effectively accomplished by the Wavelet transform technique, which provides to separate the simulated waveforms in various frequency ranges from low to high.

In deterministic approach for the low frequency ground motion simulation[4], the kinematic fault rupture mechanism (dislocation theory), replaced by the equivalent force action on the fault area, is solved for the strong ground motion simulation. The 3-dimensional wave analysis is formulated for an elastic media that includes the fault rupturing. The Laplace transform with respect to time and the Fourier transforms with respect to space on the horizontal plane are used for the moving Green Function computation. For the rupture process, the double time convolution integral was implemented by the slip function and space propagation. The inverse Laplace transform is performed analytically and the inverse Fourier transform is carried out numerically when replaced by the discrete wave number method.

In the statistical approach for the high frequency ground motion simulation, Sugito model[5] has been utilized. The model comprises construction of nonstationary spectra for the bedrock motions observed in the past earthquakes that involve parameters such as earthquake intensity, earthquake duration and rise time. The related parameters are determined by the multiple regression analysis depending on the assumed Magnitude (M) and Epicentral distance (R). The faulting system is divided into a number of subfaults in which nonstationary spectrum for each subfault is calculated and they are integrated to obtain the simulated motion for the overall faulting.

4. SIMULATION RESULTS

The simulated displacement, velocity and acceleration waveforms on the bedrock are shown in Figure 2. The maximum acceleration has been observed as 113 cm/s^2, the maximum velocity is 26.8 cm/s, and the maximum displacement 16.9 cm.

KEY WORDS: Nankai Trough Earthquake, Ground Motion Simulation, Hybrid Simulation Technique, Soft Soil Amplification
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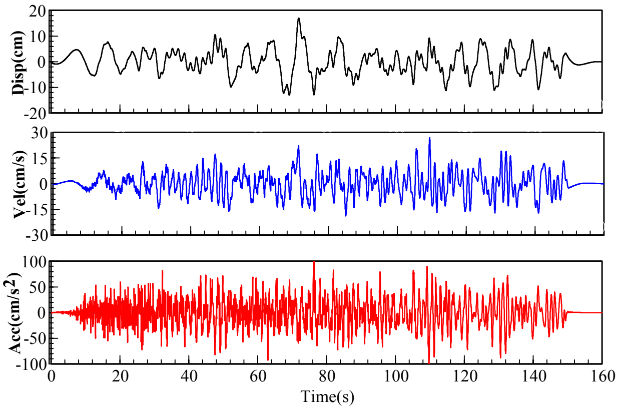

Figure 2. Simulated ground motion waveforms for K-net Okayama station on the bedrock

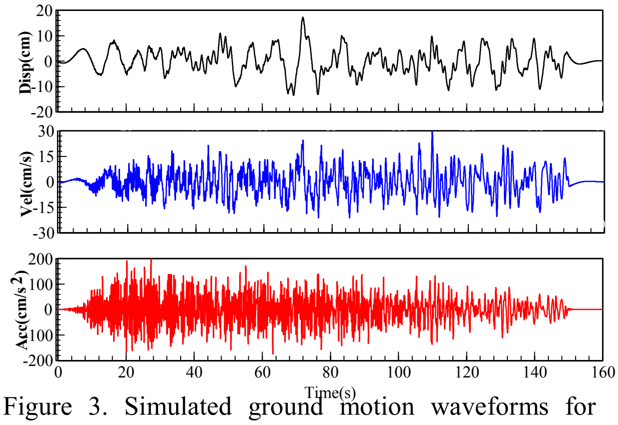

Figure 3. Simulated ground motion waveforms for K-net Okayama station on the ground surface

Soil Depth (m)	Layer Thickness (m)	Soil Type	N Value	Density (tf/m^3)	S-Wave Velocity (m/s)
2.0	2.0	AC1	1	1.75	102
6.0	4.0	AS1	5	1.95	137
8.0	2.0	AC1	1	1.75	102
14.0	6.0	DG1	30	2.10	300
26.0	12.0	DG2	50	2.10	400
		B		2.40	800

Table 1. Soil data for K-net Okayama station

It is also purposed to investigate the ground motions on the ground surface to interpret the amplification in the shallow soil deposit. The soil data for the K-net Okayama station has been obtained[6]. The simulated motion on the bedrock has been used as the input for the analysis. The simulated displacement, velocity and acceleration waveforms on the ground surface are shown in Figure 3. The maximum acceleration has been observed on the ground surface as 203.5 cm/s^2, the maximum velocity is 29.8 cm/s, and the maximum displacement 17.2 cm.

The pseudo acceleration (PSA) response spectra and the pseudo velocity (PSV) response spectra for the simulated motions on the bedrock and on the ground surface have been calculated by the statistical and hybrid methods and compared with Type II Standard Response Spectra in the Figure 4 and 5, respectively. As it can be seen both from PSA and PSV in short periods between 0.1s to 0.8s the surface ground motions indicate larger responses in both statistical approach and hybrid method. However, in the periods longer than 0.8s statistical approach shows some underestimation.

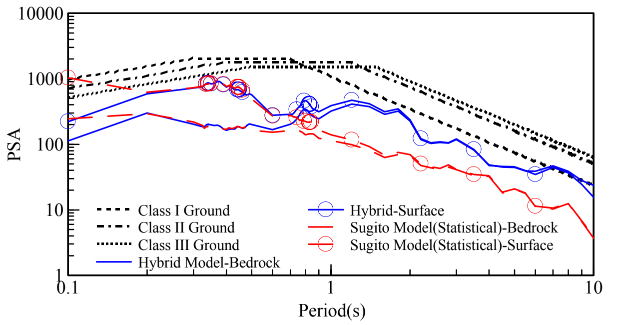

Figure 4. The comparison of PSA response spectra of simulated motions with the Type II Standard Acceleration Response Spectra

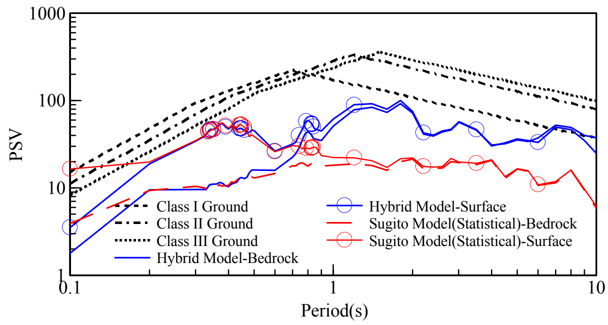

Figure 5. The comparison of PSV response spectra of simulated motions with the Type II Standard Velocity Response Spectra

5.CONCLUSION

The present simulation results show that response spectra for acceleration and velocity are far below the seismic design code values. However, shallow soil conditions may have substantial amplification effects on the surface ground motions as it has been observed in this study for K-net Okayama station in short period ranges. The long duration over 2 minutes with rather long period has a high possibility to lead a substantial nonlinear soil response and soil failure subsequently at soft sites. The deformation response may become important factor for structural deformation failure mechanism.

6. REFERENCES

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