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Benchmark Tests for Strong Ground Motion Simulations (Part 10: Numerical Methods, Step 5 & 6)

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1.Introduction

We have been conducting a benchmark test for strong motion simulation methods with numerical methods (finite difference method and finite element method). During 3 years of the research period, we studied 14 problems categorized in 6 steps with various degree of complexity from a simple homogeneous model to a realistic Kanto basin model.

In step 1, we studied a homogeneous model and a two-layer model with a point source. In step 2, we studied the two-layer model with extended source models: a lateral fault and a reverse fault. (Yoshimura et al., 2011). In step 3 and 4, we considered a four-layer model, a symmetric trapezoidal basin model and an asymmetric slant-basement basin model (Yoshimura et al., 2012). In this report, we present the results of step5 and 6 in which we considered a realistic Kanto basin model where Tokyo metropolitan area is located.

2. Problems for step 5 and 6

We considered a 3-dimensional Kanto basin model and the source models of 4 observed earthquakes. Six teams participated in this year. Table 1 shows the calculation conditions. Figure 1 shows the calculation domain (210km x 270km) with source model (stars or circles) and calculation sites (squares).

In step 5, we targeted 3 small or middle earthquakes: 1990 Western Kanagawa Prefecture earthquake (Mj 5.1), 1990 Near Izu-Oshima earthquake (Mj6.5) and 1992 Tokyo bay earthquake (Mj 5.7). We constructed the source models based on Sato T. et al. (1998) and Yamada and Yamanaka (2003).

We constructed the 3-dimensional Kanto Basin model based on the model proposed by The Headquarter for Earthquakes Research Promotion (2009). The grid size or element size were set so that the calculation results are effective at the frequency domain from 0 to 0.33 Hz. Participants turned in calculated velocity time history data for 19 sites.

In step 6, we targeted 1923 Kanto earthquake (Mj 7.9). The source model was constructed based on the inverted source model proposed by Sato H. et al. (2005).

3. An example of calculated results

Figure 2 shows the calculated Y (EW) component of velocity waves at ASK. Yoshimura calculated with FEM. Nagano, Hayakawa, Citak et al., Iwaki et al. and Kawabe calculated with FDM. In addition, Fig.2 shows Hisada's result calculated with a wave number integration method considering a flat layered model. Because ASK is a rock site, the waveform is simple. The results by FEM and FDM agree with each other. Hisada's result is similar to those results because the seismic wave mainly consists of body wave and the flat layer approximation is effective. On the other hand, at the sites on the thick sedimentary basin, the later phases induced by basin structure become dominant. Our results on sedimentary sites show generally good agreement but are not as perfect as ASK at the present moment. We are now checking reasons such as the difference of modeling of surface thin layer and are planning to revise the results.

For more details, please check http://kouzou.cc.kogakuin.ac.jp/benchmark/index.htm

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Keywords: Fault model, Finite element method, Finite difference method, Kanto plain, Kanto earthquake, Western Kanagawa Prefecture earthquake

Table 1 Calculation condition

	Step 5			Step 6
Model	N51	N52	N53	N61
Target Earthquake	1990 Western Kanagawa Prefecture Earthquake (Mj5.1)	1990 Near Izu-Oshima Earthquake (Mj6.5)	1992 Tokyo bay earthquake (Mj 5.7)	1923 Kanto earthquake (Mj 7.9)
Source model	point source Sato, T. et al (1998)	plane source Yamada and Yamanaka(2003)	point source Yamada and Yamanaka(2003)	plane source Sato, H et al. (2005)
Subsurface structure model	3 dimensional Kanto Basin model constructed based on "Long period ground motion prediction map 2009" by The Head quarter for Earthquake Research Promotion			
Attenuation	Yes			
Frequency	0~0.33Hz			
Output	19 sites			

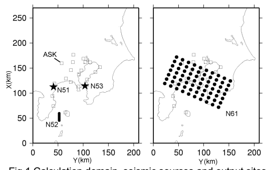

Fig.1 Calculation domain, seismic sources and output sites

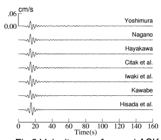

Fig.2 Velocity waveforms at ASK