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Several issues revealed from benchmark tests for strong ground motion simulations (Part 2: Numerical methods)

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1. Introduction

Numerical methods such as 3-dimensional finite difference method and 3-dimensional finite element method are often used to calculate long period earthquake ground motions in large sedimentary basins such as Kanto, Nobi and Osaka plains in Japan. These methods can consider complex source model and irregular subsurface ground model, however, the differences of modeling lead to differences of calculated ground motions. We have conducted a benchmark test for 3 years since 2009. In this presentation, we summarize the issues revealed from the benchmark study. We also show a newly proposed benchmark test targeting the source region along Nankai trough, in western Japan, where large subduction earthquakes are supposed to occur in near future.

2. Several issues revealed from benchmark test (2009-2012)

In step 1 and 2 during 2009, we studied a uniform media and a two-layered media with a point source or a rectangular source. The waveforms calculated by 6 teams showed generally good agreement to each other. However, the results showed differences depending which properties are allocated at the grids just on the boundary between the surface layer and the basement layer.

In step 3 and 4 during 2010, we considered two simple sedimentary basin models: a symmetric trapezoidal basin and an asymmetric slant-basement basin. In the process of discritization of subsurface ground model, differences of properties allocation among teams appeared near the curved boundary or along the slant basement. It generated differences at the waveforms of surface waves.

In step 5 and 6 during 2011, we solved a realistic Kanto basin model considering 3 observed small or medium earthquakes and the 1923 Kanto earthquake. The waveforms of body waves showed good agreement among teams. However, those of surface waves showed differences among teams whose grid space are different. Choice of grid space makes differences regarding allocation of soil properties along depth near the surface. It affects the accuracy of surface waves that propagate long distance in horizontal direction.

As mentioned above, the modeling of soil structure near the surface is important because it affects the accuracy of surface waves that are dominant in long-period domain the numerical methods consider.

3. Outline of the newly proposed benchmark test

The benchmark test is to simulate the southeast off the Kii peninsula earthquake (Mj 7.1) that occurred in the source region along Nankai trough on September 5th, 2004.

Table 1 summarizes the calculation condition. Figure 1 shows the source location and output points. Calculation domain is to be chosen so that it includes any one of Kanto, Nobi and Osaka plain, or more than one plain. Source model is to be the one proposed by Yamamoto and Yoshimura (2012). The subsurface ground model of Kanto plain is to be build based on the model proposed by "Long period earthquake ground motion prediction project in 2012 (2012 model)". For Nobi and Osaka plain, the 2012 model is to be used for the lower crust and deeper, and the 2009 model for the upper crust and shallower. The calculation is to be valid up to 0.25 Hz for Kanto plain and up to 0.4 Hz for others. Five to 10 output points are selected for each plains and 5 points along propagation path to each plain as shown in fig.1.

The details of the benchmark test are available at http://kouzou.cc.kogakuin.ac.jp/test/home.htm.

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Table 1 Calculation condition

	Step 7
Model name	N71
Target Eq.	Southeast off the Kii Peninsula Eq. (2004/9/5, 19:07, M7.1)
Source	Point Source
Soil model	Kanto plain: Long period earthquake ground motion prediction model 2012 Nobi and Osaka plain: 2009 model + 2012 model
Attenuation	Yes
Calculation frequency	Kanto plain : 0~0.25Hz (more than 4s) Nobi and Osaka plain : 0~0.4Hz (more than 2.5s)
Output	5~10 points in each plain、5 points on the path to each plain

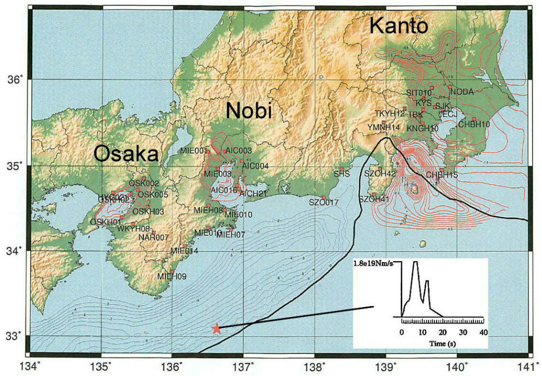

Figure 1 Source and output points