Advanced Methods on the Evaluation of Design Earthquake Motions for Important Power Constructions

Background

In recent years, the circumstances surrounding the evaluation of design earthquake motions for important electric power constructions have been changing. For the nuclear power facilities, "NSC (Nuclear Safety Commission) Regulatory Guides for Reviewing Seismic Design of Nuclear Power Reactor Facilities" were revised on 19 September 2006. In addition, the occurrence of the Niigataken Chuetsu-oki Earthquake in 2007 has had a great influence on the review. For the thermal power facilities, the counter-measure against sloshing behavior in the oil tanks became a big issue after the Tokachi-oki Earthquake in 2003. The seismic design for the hydroelectric power facilities needs to deal with "Draft of Guidelines for Seismic Safety Evaluation of Dams" submitted by the Ministry of Land Infrastructure and Transport (MLIT). It is required to use appropriate methods as the periods and ground conditions for the evaluation of design earthquake motions vary with the power constructions.

Objectives

The purpose of this study is to improve and compile our elemental technologies on earthquake motion evaluation to provide appropriate methods for various types of power constructions (Fig. 1).

Principal Results

1. Deterministic evaluation of earthquake motions

(1) We developed an inversion technique of source process with a broadband period of more than 0.1 second, while conventional techniques have a limited period range of more than 1 second. The method was applied to the Niigataken Chuetsu-oki Earthquake in 2007 and was verified for validity from comparisons of the calculated waveforms with the recorded seismograms (Fig. 2).

(2) We improved the modeling techniques of thick sedimentary layered structure such as the S-wave velocity modeling by using microtremor array measurement and the frequency dependent damping factor with a lower limit. The validity of the techniques was assessed by comparing them with the observed data at several sites and numerical simulations.

(3) An interim design pseudo-velocity response spectrum was proposed for seismic isolation design for nuclear power facilities. The spectrum is based on the recent findings on the long-period ground motions which occurred in the Tokachi-oki Earthquake in 2003.

(4) We simulated earthquake motions in the Kanto Plain by using the three-dimensional finite difference method and found that the irregularly-shaped seismic basement beneath the Kanto Plain will excite and amplify long-period surface waves and that pseudo-velocity response of the ground at a period of several to more than a dozen seconds, which is important for sloshing behavior of oil tanks etc., depends on the depth of the seismic basement.

2. Evaluation of earthquake motions based on probabilistic seismic hazard analysis

We introduced a probabilistic approach to make a selection of a scenario earthquake or to make a design spectrum depending on the level of seismic hazard into "Draft of Guidelines for Seismic Safety Evaluation of Dams" submitted by the MLIT, which is the deterministic evaluation method.

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Reference

S. Higashi, et al., 2009, "Advanced Methods on the Evaluation of Design Earthquake Motions for Important Power Constructions", CRIEPI Report N04 (in Japanese)

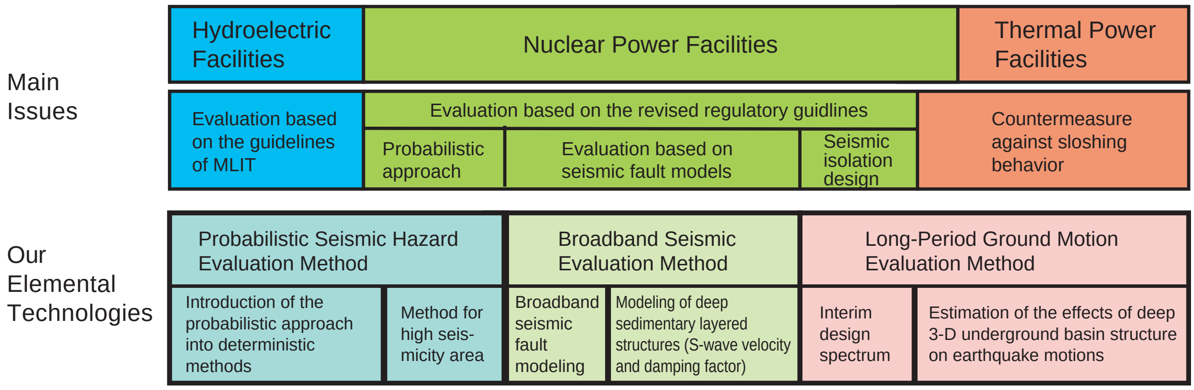

Fig.1 Issues of important power facilities and elemental technologies on evaluation of earthquake motions.

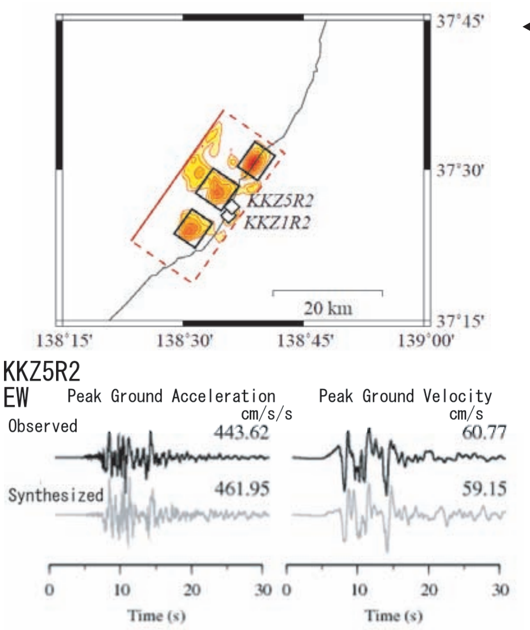

Fig.2 Estimated slip distribution model of the Niigataken Chuetsu-oki Earthquake in 2007 (upper part of the figure on the left) and comparisons of the observed and synthesized waveforms at KKZ5R2 in the TEPCO Kashiwazaki-Kariwa nuclear power plant (lower part of the figure on the left).

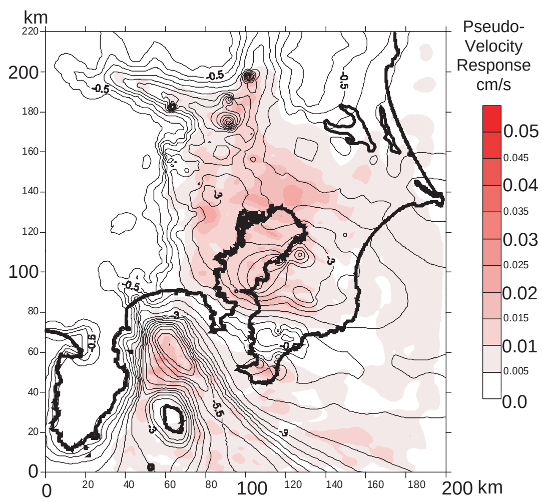

Fig.3 An example of the pseudo-velocity response distribution at the period of 8 sec. in the Kanto Plain (h=0.01). Contour lines represent the depth of the seismic basement (unit: km).

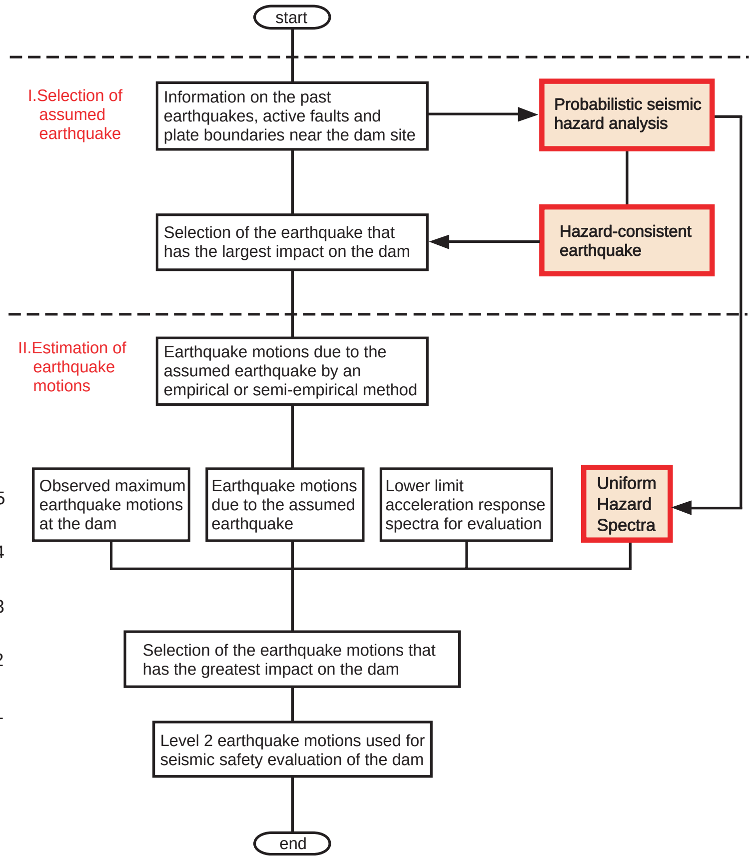

Fig.4 An example of the introduction of the probabilistic approach into the MLIT guidelines for seismic safety evaluation of dams (red boxes).