Identification of Damping Factor of Foundation Ground of Nuclear Power Plants Based on Earthquake Observation Records

Background

The stability evaluation of the foundation ground where a reactor building is set up is one of the important items in the earthquake safety evaluation of nuclear plants. Ordinarily, the stability evaluation of the foundation ground is conducted by numerical simulation using two-dimensional FEM analysis. In case of the simulation for hard rock sites, it is general to use commonly used damping factor of the foundation ground, which is invariant for frequency and shear stain. Therefore, in order to examine the validity of present ground stability evaluation method, it is necessary to estimate the characteristics of damping factor of hard rock at existing nuclear power plants.

Objectives

To examine the differences between damping factor of hard rock ground and commonly used damping factor in stability evaluation of foundation ground, we identified damping factor of hard rock ground by using borehole array data recorded in hard rock ground at existing nuclear power plants. Moreover, we clarified influences of the damping factor of ground on the stability evaluation (safety factor of the foundation ground).

Principal Results

1. Survey of actual conditions of damping factor in ground stability evaluation and identification of damping factor based on earthquake observation records

We conducted a survey of the actual conditions of damping factor in ground stability evaluation at 10 existing nuclear power plants, and the damping factor of two sites was identified based on earthquake observation data. In this study, a spectral ratio inversion method using new representational model that is able to deal with lower limit of damping factor was proposed for identifying material damping (Fig.1). The results from this study are shown as follows.

(1) In the ground stability evaluation of the existing power plant, a damping factor of 0.03(3%) was used as the commonly used damping factor at 80 % of points in the investigated plants.

(2) From the inversion results using the proposed model of damping factor, it was found that lower limits of damping factor were distributed between about 0.03(3%) and 0.05(5%) for the rock ground of S-wave velocity of less than 2,000m/s, and between about 0.003(0.3%) and 0.09(0.9%) for S-wave velocity of more than 2,000m/s. According to the laboratory test results, the lower limit of proposed model of damping factor corresponds to material damping. Therefore it is reasonable to interpret that the commonly used damping factor expresses the material damping factor of hard rock ground of S-wave velocity of less than 2,000m/s.

2. Influences of damping factor on foundation ground stability evaluation

We estimated the influence of the damping factor on the ground stability evaluation by 2D dynamic FEM analysis of hard rock foundation ground considering 8 slipping lines using 7 combinations of damping factor. As a result, it was demonstrated that the safety factor increases against the increase of damping factor in shallower slipping lines, and hardly changes against the damping factor in deeper slipping lines. From these numerical simulations, it was understood that the results of ground stability evaluation by using commonly used damping factor are on the safe side.

Future Developments

We will apply the developed inversion method to borehole array data recorded in soft rock and soft soil ground, and clarify the attenuation mechanism of seismic motion.

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Reference

H. Sato et.al., 2005, “Attenuation characteristics of seismic motion based on earthquake observation records -Identification of damping factor at hard rock sites and its influences on ground stability evaluation-”, Technical Report N04041 (in Japanese)

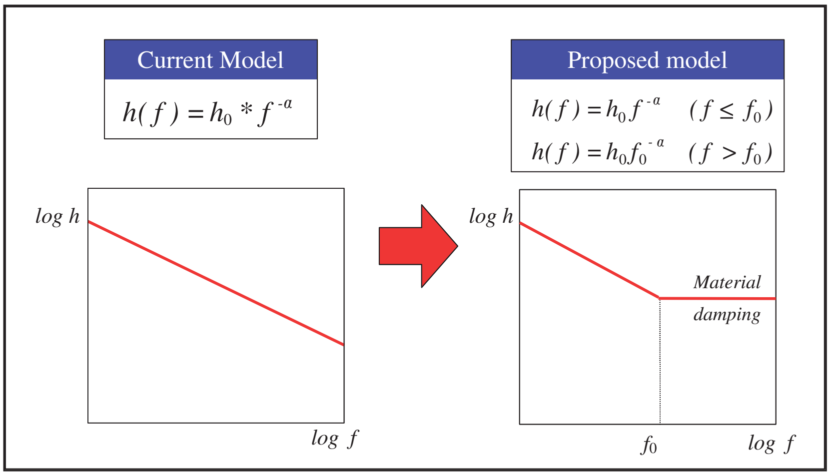

Fig.1 Schematic illustration of new representation model of damping factor

The proposed model of damping factor shows the frequency dependency up to frequency f_0, and shows constant value (lower limits of damping factor) at high frequency.
From inversion results, it was found that the lower limit of proposed model of damping factor corresponds to material damping.

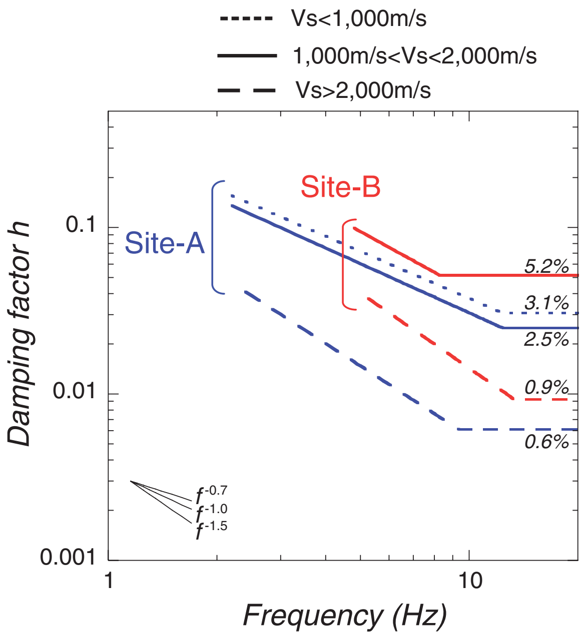

Fig.2 Identified damping factor of hard rock ground by using borehole array data recorded inhard rockground at two existing nuclear power plants

The damping factor of two sites was identified based on the earthquake observation data.
From inversion results, it is reasonable to interpret that the commonly used damping factor expresses material damping factor of hard rock ground of S-wave velocity of less than 2,000m/s.

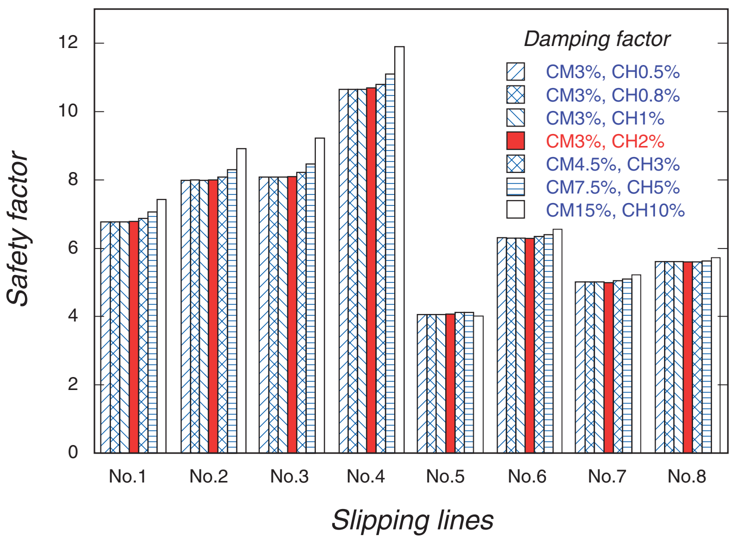

Fig.3 Influence of damping factor on foundation ground stability evaluation (Safety factor)

We conducted 2D dynamic FEM analyses of hard rock foundation ground considering 8 slipping lines using 7 combinations of damping factor.
From these numerical simulations, it was demonstrated that the safety factor increases against the increase of the damping factor in shallower slipping lines, and hardly changes against the damping factor in deeper slipping lines. These results imply that the results of ground stability evaluation by using commonly used damping factor are on the safe side.