Priority Subjects with Limited Terms — **Establishment of Optimal Risk Management**

Improvement of Safety Assessment Technologies on External Natural Hazards for Nuclear Facilities

Background and Objective

The Fukushima Daiichi nuclear accident has seriously impacted upon the reliability of nuclear safety and social trust. Most nuclear power plants are currently shut down for these reasons. Long term shutdown should be avoided as nuclear power has the potential to play an important role for realizing a low carbon society. In this project, safety assessment methodologies for nuclear power plants subjected to natural disaster are studied.

Main results

1 Development of a simple method for estimating tsunami hydrodynamic loads

In order to evaluate the fragility of facilities and structures against great tsunamis, a novel and rational method for estimating tsunami hydrodynamic loads was proposed. By using the proposed method, tsunami hydrodynamic loads can be estimated simply and accurately from the specific energy of tsunami flow. Hydrodynamic loads predicted by the method were compared with those obtained by three-dimensional numerical simulations using the computational fluid dynamics code SLOSH-NAGARE, showing good agreement between them (Fig. 1). The proposed method will be validated under a wide variety of conditions in the future.

2 Verification analysis of an evaluation method for rock mass attainment area due to slope collapse

An evaluation method of rock mass attainment area due to slope collapse is developed to research the influence of peripheral slope collapse of nuclear facilities on safety. This evaluation method is based on numerical analysis by a three-dimensional distinct element method (DEM) assuming rock mass collision and rebinding during a slope collapse. Numerical simulation of a slope collapse by shaking a table was conducted to verify the analysis method. For this simulation, rock mass models which express the three-dimensional proportions of the rock mass used in the experiment are created and a set-up procedure of analytical parameter based on coefficients of restitution and friction is suggested. As a result, the volume of falling rock mass and attainment area by experiment are successfully reproduced and validity of our analysis method is shown. The remaining issue is on-site slope collapse analysis.

3 Development of equipment for obtaining fault samples by large-scale rotary tube sampling

The purpose of this research is to improve reliability of the stability evaluation method of the ground foundation and surrounding slope of a nuclear power plant. We developed sampling equipment which obtained undisturbed fault samples 20cm in diameter to investigate the mechanical properties (two patent applications). The features of the equipment are that rotary motors are installed immediately above the core barrel to suppress rotational vibration, a rubber sleeve is placed on the core in the core barrel to enable direct installment in a tri-axial apparatus and the lower end of the core is cut and retrieved by the core bits divided into three parts which arch out into the lower end. The performance tests of the equipment were carried out on tuffaceous rock in a laboratory. We will conduct sampling in the field to test the effectiveness of the equipment.

4 Development of numerical simulation for eruption columns to improve assessment of volcanic ash-fall

The numerical assessment method of volcanic ash-fall is improved through the development of simulation on an eruption column and transport and diffusion of volcanic ash-cloud and ash-fall. The non-linear, three-dimensional simulation of an eruption column was developed. For the simulation of real-scale eruption columns, the eruption cloud shape varied with the velocity at the vent. Moreover, the turbulent model considerably affected the simulation results for real-scale eruption columns (Fig. 4, N12003).

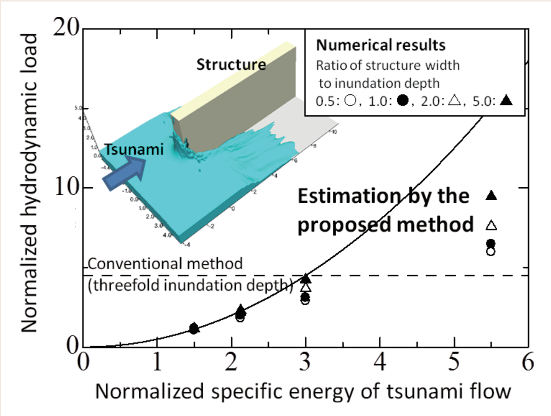


Fig. 1: Comparison between tsunami hydrodynamic loads predicted using the proposed method and those obtained by three-dimensional numerical simulations

In order to validate the proposed method for estimating tsunami hydrodynamic load, three-dimensional numerical simulations of a tsunami were carried out and the hydrodynamic loads on a structure were calculated with four ratios of the structure width to tsunami inundation depth and four Froude numbers. The comparison in the figure confirms the validity of the proposed method and the hydrodynamic load predicted by the conventional method, in which the hydrodynamic load is expressed as a hydrostatic load of threefold inundation depth, is overestimated in the low tsunami energy regime.

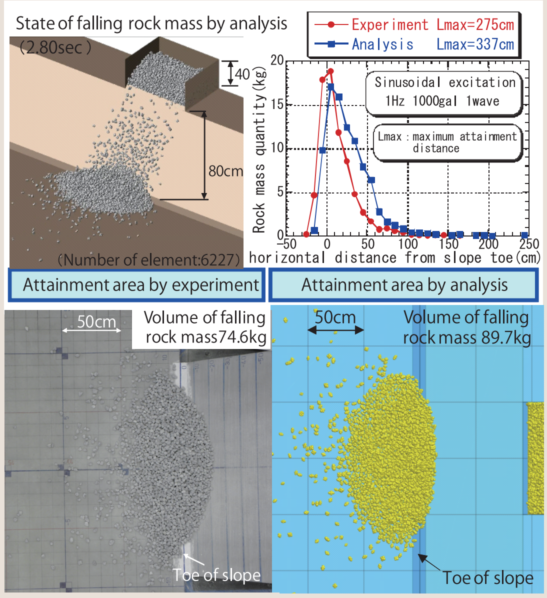


Fig. 2: Verification of evaluation method of rock mass attainment area due to slope collapse by numerical simulation of shaking table test

For verification of the evaluation method of rock mass attainment area due to slope collapse, a numerical simulation of a shaking table test was conducted. As a result, the volume of falling rock mass and attainment area by experiment are successfully reproduced and the validity of our analysis method is shown.

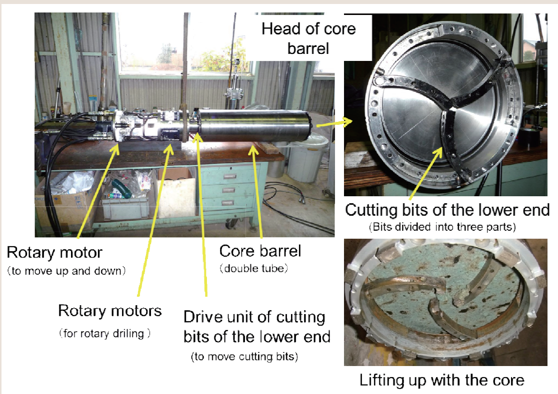
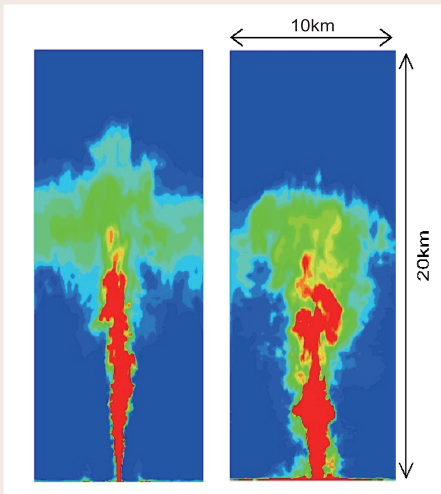


Fig. 3: Sampling equipment using a large-scale rotary tube

We proposed and developed sampling equipment to obtain undisturbed fault samples 20cm in diameter (two patent applications). We successfully experimented with a prototype on the tuffaceous rock in the laboratory and verify the cutting of the lower end of the core and insertion of the core into rubber sleeve.



(a) Smagorinsky model, (b) Yuu model
Velocity at vent is 200m/s for both models.

Fig. 4: Effect of turbulent model on eruption column shape

The volume fraction of volcanic ash particles within the eruption column is calculated by the developed turbulent model. The simulation results show that the selection of turbulent model significantly affects eruption column shape.