# Project Subjects

## Seismic Margin Evaluation of Civil-engineered Structures at Nuclear Power Plants

### Background and Objective

Since the Nuclear Safety Commission revised the Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities in 2006, electric power companies have been required to reevaluate the seismic safety of existing nuclear power plants (back-checks), seismic margin evaluation, residual risk evaluation, etc. in response to public concerns about the seismic safety of nuclear power plants. The seismic margin evaluation aims to facilitate public understanding with respect to seismic safety of nuclear power plants by the quantitative evaluation of seismic margin.

The purposes of the project are to investigate the limit of strong-ground motion, the functional limit strength of structures, and to show how to communicate the risks with citizens in order to establish seismic margin evaluation method for civil-engineering structures at nuclear power plants.

### Main results

#### 1. Simultaneous rupture evaluation of active fault segments

It is important to estimate the simultaneous rupture of active fault segments for seismic design of nuclear power plants. In order to detect important factors in the propagation of fault ruptures, we performed morphological, geological and geophysical surveys around the step-over between the two active faults which moved in the 1891 Nobi earthquake (Fig. 1). As preliminary results, it may be inferred that (1) the fault structure in a step-over and step-over length, and (2) abrupt change of seismic velocity structure are important factors.

#### 2. Evaluation of tensile strength and dynamic characteristics of rock mass

When an enormous earthquake occurs, the foundation ground under a reactor building and the surrounding slopes are subjected to tensile stress. The tensile strength has been estimated to be zero for various reasons, for instance, the reliable tensile strength of the rock mass has not been able to be measured in the field. We developed a uniaxial tension test apparatus (Fig. 2) that can measure the tensile strength of rock mass in the field for the first time in the world to show that the foundation ground and the surrounding slopes will withstand strong larger-than-expected ground motions.

#### 3. Flowchart of seismic stability assessment of rock slopes

A new seismic stability assessment flow for surrounding rock slopes, which includes evaluation of the influence of sliding blocks, was proposed. The experiments concerned with the maximum rolling distance of rocks were conducted [N09029]. The way to separate a sliding surface which is able to fall through the weight of sliding blocks from a sliding surface which only moves during an earthquake was also included [N09030].

#### 4. Development of methods for seismic margin evaluation and risk communication

It is required that we clarify the relationship between seismic margin and risk for structures because the government of Japan may quantitatively prescribe safety targets based on probabilistic risk. Therefore, we propose a diagram which relates to structural seismic margin (the difference between limit and design value) to seismic risk (residual risk). This diagram makes it possible to estimate the seismic risk level based on the deterministic seismic margin.

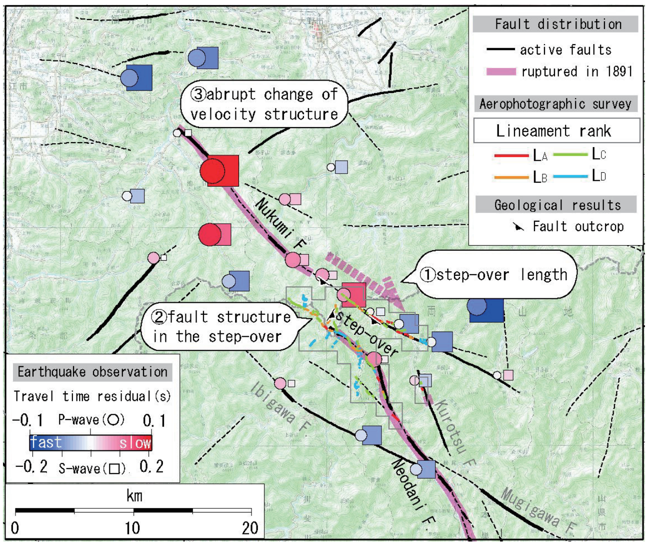


**Fig. 1 Possible factors in the propagation of earthquake ruptures around the step-over between the Nukumi and Neodani faults in the 1891 Nobi earthquake fault system**

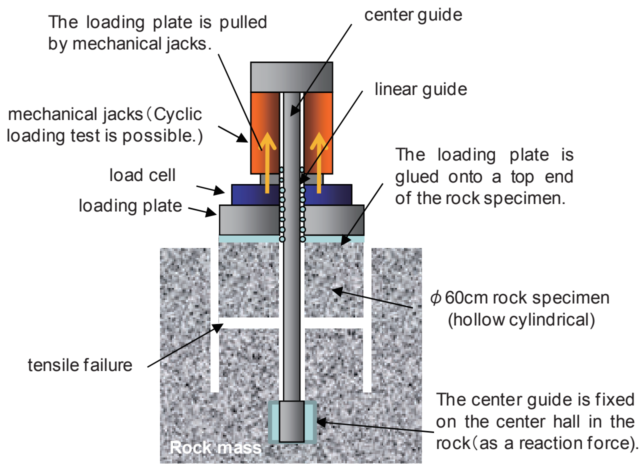


**Fig. 2 Uniaxial tension test apparatus**

The rock specimen is pulled along the center guide using mechanical jacks.

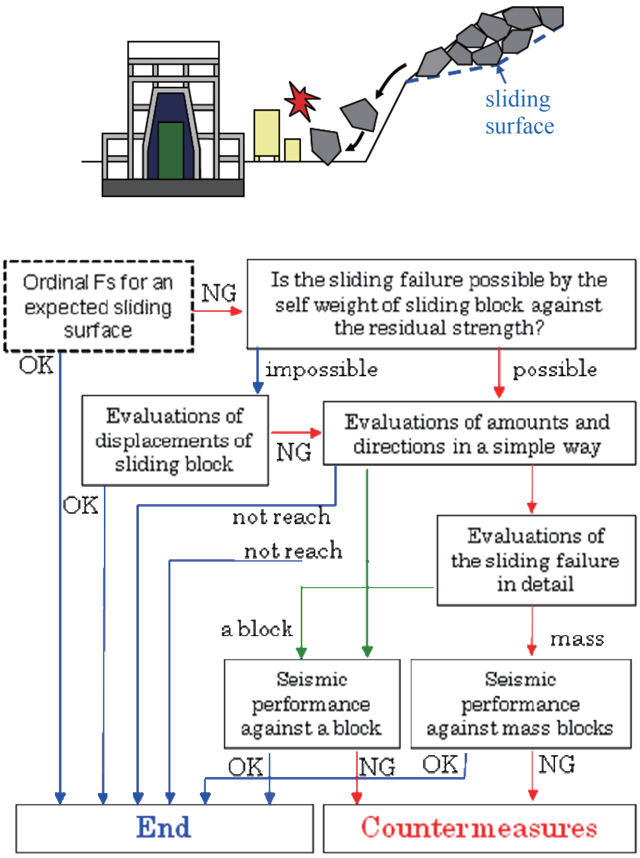


**Fig. 3 Flowchart of seismic stability assessment of rock slopes**

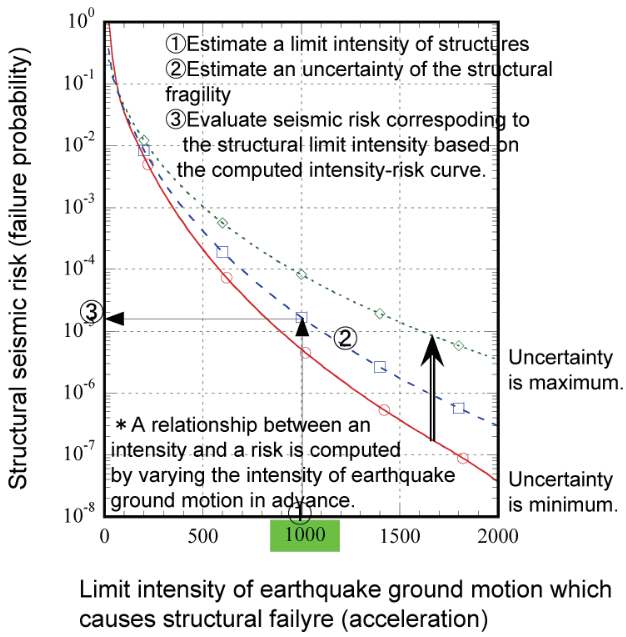


**Fig. 4 Structural capacity (limit acceleration) vs. seismic risk**

We can relate seismic margin which is defines as structural capacity (i.e. limit acceleration) to seismic risk (annual failure probability) based on the seismic hazard curve for a site and structural fragility curve.