

11-3 How Do Earthquake Waves Propagate into a Nuclear Facility?

— Realization of Precise Simulation of Building-Equipment Interaction during Earthquakes —

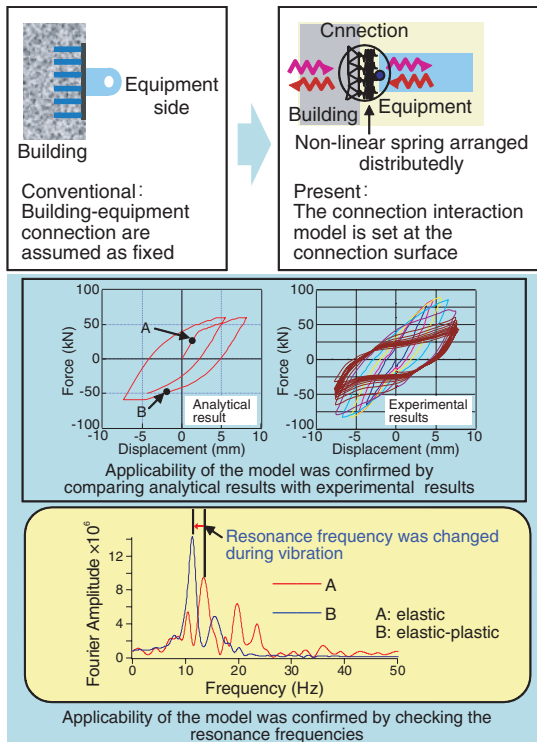
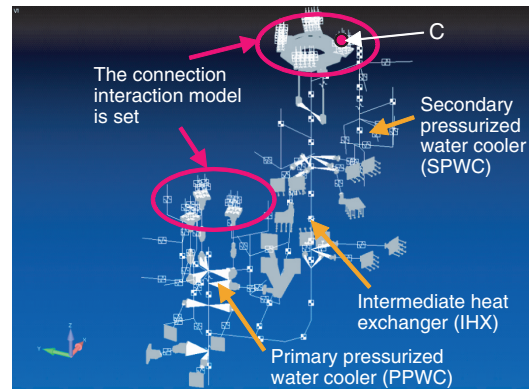


Fig.11-5 Connection interaction model between buildings and equipment

We compared the analysis results from the suggested connection interaction model with experimental results and confirmed the applicability of the suggested model to the real connection structure.

Nuclear facilities are composed of a large number of equipment, and it is necessary to evaluate realistic responses of each of these equipment to earthquakes in order to ascertain earthquake resistance safety. In particular, it is important to know which types of wave propagate into the building through the connection; in other words, it is important to know the detailed wave propagation properties of the connection (wave transmission and reflection), because equipment response is evaluated using building response. Because the connection between buildings and equipment is a concrete structure, it is usually assumed to be a fixed boundary to simplify the elucidation of its wave propagation properties. However, recent experimental results have suggested that a slight displacement or gap can occur at the connection for large inputs, and it has become clear that the assumption of a fixed boundary is not appropriate in such instances.

Therefore, we have attempted to express wave propagation properties at the connection to model force-displacement relationships based on experimental data. We devised force-displacement relationships for each micropart directly by arranging nonlinear springs dispersively on the boundary surface in order to consider historical properties such as the partial gap at the connection. We confirmed the applicability of the connection interaction model by comparing our analytical results with experimental results and confirmed the resonance frequencies before and after the nonlinearization of



Analytical model for whole numerical simulation of primary cooling system of HTTR

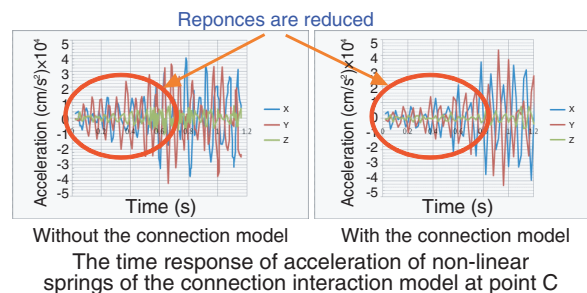


Fig.11-6 Real entire-plant analysis with connection interaction model

We incorporated the connection interaction model into the real plant model and conducted earthquake response analysis. The results indicate that the equipment response was reduced by absorption of energy as a result of the nonlinearization imparted by connection; thus, we were able to confirm the effects of adopting the connection interaction model.

the connection, as shown in Fig.11-5.

Furthermore, we conducted earthquake response analysis of the entire cooling structure of a nuclear facility incorporating the connection interaction model using a large earthquake input, for which part of the building-equipment connection becomes nonlinearized, to confirm the applicability of the connection interaction model to the real plant. Fig.11-6 shows a model of the entire cooling structure of the high-temperature engineering test reactor (HTTR) and our analysis results. We were able to confirm that the equipment response was reduced because of historical energy absorption by nonlinearization of the connection in the case with the connection interaction model. On the basis of these results, we were able to assess the potential for use of the connection interaction model in earthquake resistance evaluation.

It is expected that more detailed analysis will be necessary for evaluation of the earthquake resistance of nuclear plants. Furthermore, we expect that as the representation of the behavior of nuclear facilities during earthquakes improves, we will be able to share more detailed information with the general public.

The present study is the result of the project entitled "Development of physical model describing the dynamic interaction characteristics of component connections for the analysis of an entire nuclear facility" entrusted to the Japan Atomic Energy Agency by the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT).

Reference

Nishida, A. et al., Elastic-Plastic Connection Model Describing Dynamic Interactions of Component Connections, Progress in Nuclear Science and Technology, vol.2, 2011, p.576-581.