ON PROVING TEST OF EARTHQUAKE RESISTANT PIPING AND ACTIVE COMPONENTS

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SUMMARY

In Japan, we started the project of a shaking table to prove the earthquake resistant properties of key items in nuclear power stations. This two-axial shaking table, which will be able to shake a 1000 ton object on a table of 15 m × 15 m by 2600 ton G in horizontal force and by 1300 ton G in vertical force. In this paper, the philosophy of such projects will be described. And also various experiences on such proving tests done in Japan will be described.

Main purposes of proving tests are as follows:

(1) knowing the behaviors of nuclear structures and equipment under strong earthquakes both in the viewpoints of structural dynamics and process dynamics;
(2) knowing the endurance limits of structures and equipment to destructive earthquakes both in the viewpoints of structural integrity and operational function;
(3) knowing the behaviors and availabilities of active components under deformations and accelerations induced by destructive earthquakes;
(4) understanding the margin of safety of structures and equipment under assumed destructive earthquakes conditions both for the society and related engineers.

Although we have almost eleven centuries historical data of earthquake damage, still we learn some new facts on every new destructive earthquakes. We have almost no experience on earthquake damages of nuclear structures and equipment. We have been doing our best to estimate the "modes of failure" of various structures and items in nuclear power stations. Therefore, we should be afraid of lack of knowledge on that, because earthquakes are natural phenomena and have somewhat unpredictable nature. However, we can understand the behavior of structures and equipment in their ultimate condition through shaking test.

One of our uncertainties on the earthquake effects is the effect of vertical ground motions. Three-dimensional response seems to be nothing particular, however, overturning and unstable moving of a solid structure are one of highly non-linear problems. The behavior of free-surface water in a containment under three-dimensional excitation is not known completely also. These things can be clearified only through shaking experiment using two- or three-dimensional shaking table including vertical component motions.

Availabilities of active components, such as control rod driving mechanisms, valves and pumps can be checked only through shaking and/or forced deformation test, because troubles of such active components may be induced by mechanical friction or contact of moving portions. Malfunctions of electrical components are also complicated, for example chattering of the contact of relays. To evaluate behaviors of such active components and electrical components, so-called mathematical model is powerless. It is almost impossible to establish an adequate mathematical model of those components including all elemental factors related to its function.

In Japan, we have many experiences of shaking tests of various size models and for various purposes, not only for nuclear power stations, but also other areas. Their philosophy, methodologies and results will be briefly described.