1-8 Ultimate Behavior of Seismically Isolated FBR Plants in Huge Earthquake

－Large Shaking Table Test of Horizontal Isolation System－

Fig.1-19　Horizontal isolation system test apparatus
Shaking table tests for the breaking of the laminated rubber bearing were performed on a scale as large as any in the world. The response reduction function in a tentative model of ground motion was confirmed, and the ultimate behavior data of the system in response to ground motion four times greater than the model were measured.

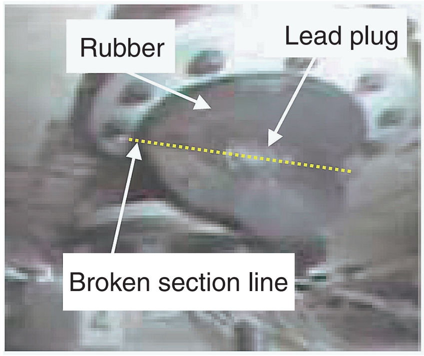

Fig.1-20　Moment that laminated rubber bearing broke
This photograph taken with a video camera shows the moment that a laminated rubber bearing broke. Breaking started from the edge of the rubber, and pieces of the lead plug were ejected when the bearing broke.

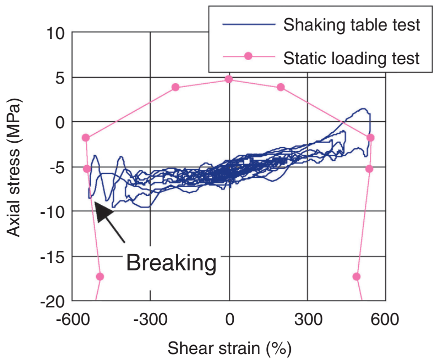

Fig.1-21　Breaking strain of laminated rubber bearing
The solid line shows the relation between the axial stress and the shear strain during a shaking table test where the laminated rubber broke. The pink line plots the breaking conditions, based on a static loading test. The breaking strain measured in the shaking table test was almost the same value as that of the static loading test.

Seismic isolation technology is to be introduced into fast breeder reactor plants of the next generation in order to reduce the seismic load subjected to components. To grasp the ultimate behavior of a base isolated plant in a huge earthquake of a level higher than that considered in the design, we made ultimate behavior tests of seismically isolated FBR plants with a large shaking table, in cooperation with Central Research Institute of Electric Power Industry.

A seismic isolation effect is achieved by setting up soft springs (laminated rubber bearings) under the building so that the building may shake slowly. The relation between the load and the displacement of the rubber bearing is almost linear in the range where the load is small. A seismic isolation system is designed so that the building may also respond linearly to the seismic intensity. When the seismic load is large, the seismic isolation effect is lost because of the hardening of the rubber, which then may break. In this test, data concerning the loss of the isolation effect and the breaking behavior of rubber were obtained.

One of the world's largest three-dimensional shaking tables, “E-Defense” of National Research Institute for Earth Science and Disaster Prevention, was used to observe actual behavior of the isolation system. Fig.1-19 shows the shaking table test apparatus. The test specimen was composed of a superstructure of about 600 tons and six rubber bearings of 505mm outside diameter (about 1/3 the size of the prototype). There was seismic isolation of the ground motion on the scale considered in the design. After motion was increased, non-linear response in the hardening range and breaking of the rubber were observed. When the ground motion was amplified from 4.0 to 4.8 times the design level, some laminated rubber bearings broke (Fig.1-20). The breaking strains were from 550 to 600%, which agreed with the breaking conditions observed in static loading tests (Fig.1-21).

This breaking test of the laminating rubber bearing of a diameter of 505mm that are 1/3 of the prototype bearing was done on a scale without precedent. The risk evaluation method of seismically isolated plants will be developed based on these data in the future.

Reference

Kitamura, S. et al., Shaking Table Tests with Large Test Specimens of Seismically Isolated FBR Plants Part1: Response Behavior of Test Specimen under Design Ground Motions, Proceedings of the 2009 ASME Pressure Vessels and Piping Division Conference (PVP 2009), Prague, Czech, 2009, paper PVP2009-77614, 8p., in CD-ROM.