V. RESPONSES OF A THREE-DIMENSIONAL EARTHQUAKE ISOLATION DEVICE TO NATURAL EARTHQUAKES

by

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A THREE-DIMENSIONAL ISOLATION DEVICE USED FOR RESPONSE MEASUREMENT

Measurement of responses of a three-dimensional isolation device to natural earthquakes has been done since February 1984[1]. The isolation device used for the measurement was developed for light equipment, especially semiconductor manufacturing equipment[2,3]. Its structure is shown schematically in cross-section in Fig.1. In this devide, two pairs of linear motion elements crossing at right angles ensure that the table on which the equipment is mounted moves in horizontal translation without rotation, while a link mechanism provides vertical movement without tilt. Each linear motion element consists of a main rail and thinner restraining sub-rail to prevent the equipment from stepping off the main rail. Roller bearings between them support the vertical load and side roller bearings (omitted in Fig.1)on the side of the main rail prevent the equipment from rotation. The isolation device is equipped in each direction with coil springs to provide a restoring force, oil dampers for energy absorption and friction dampers to fix the system in place during normal operation and provide further energy absorption. Oil dampers for each horizontal movement are installed in a direction at right angles to the movement. This enables normal car shock absorbers to follow large horizontal

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displacements of the device as required for earthquake isolation without exceeding their maximum stroke, and gives them nonlinear damping characteristics to produce an increasing coefficient of damping with the displacement, which is considered preferable for earthquake isolation.

Excitation tests were carried out for the application to precision equipment supported by air bags using the two-dimensional, horizontal-vertical, shaking table with dimensions of 3.0 × 3.0 m. The isolation device and the equipment model used are shown in Fig.2. Further excitation tests were carried out for the implementation to equipment containing reservoirs of acids. Figure 3 shows the isolation device (installed on a supporting structure) and one of the equipment models used for the tests. Both tests were done with satisfactory results. It was confirmed the performance of the isolation device met requirements.

AN EXAMPLE OF MEASURED RESPONSES

The measurement has been done using the isolation device used for the first tests mentioned above with a more simple equipment model (Fig.5). The system was installed on the third floor of a four-story building constructed to measure soil-structure interactions during earthquakes at the Chiba Experimental Station of the Institute of Industrial Science near Tokyo (Fig.4). So far the friction dampers of the device have been released so that the device will work even in weak earthquake excitation.

Figure 6 shows the measured responses of the device to the natural earthquake on October 4, 1985, together with the 1st and 3rd floor responses of the building. These records show that, even in such a weak earthquake, the isolation device is able to reduce the response acceleration of the equipment model to 1/5 ∿ 1/4 of the floor acceleration in each horizontal direction. The performance for vertical isolation, however, was not as good as for horizontal isolation. This is because the friction in the link mechanism to prevent the equipment from rocking motion is not small enough for vertical isolation in such a weak earthquake.

REFERENCES

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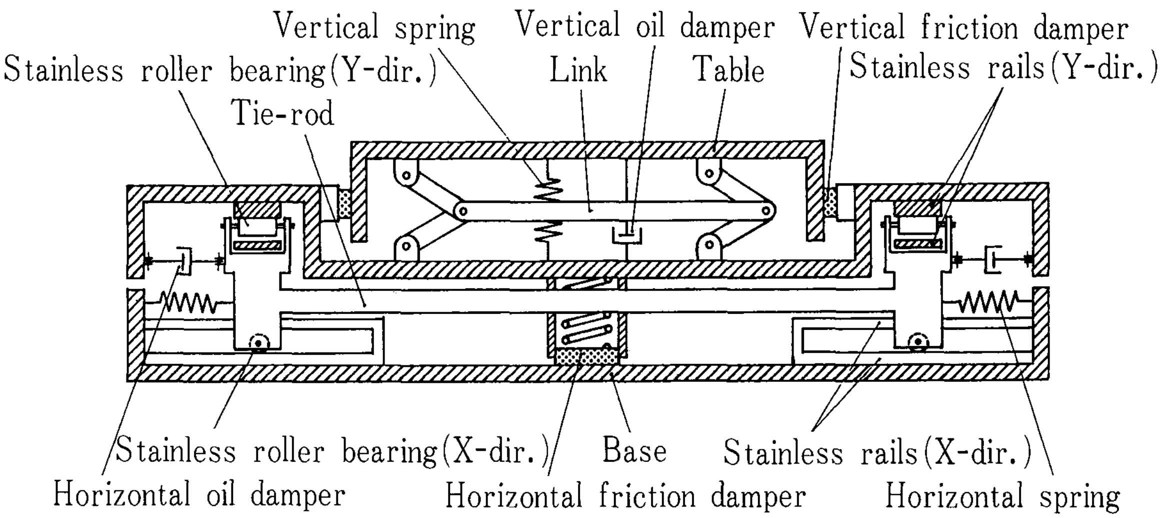

Fig.1 Schematic Drawing of a Three-Dimensional Earthquake Isolation Device (in cross-section).

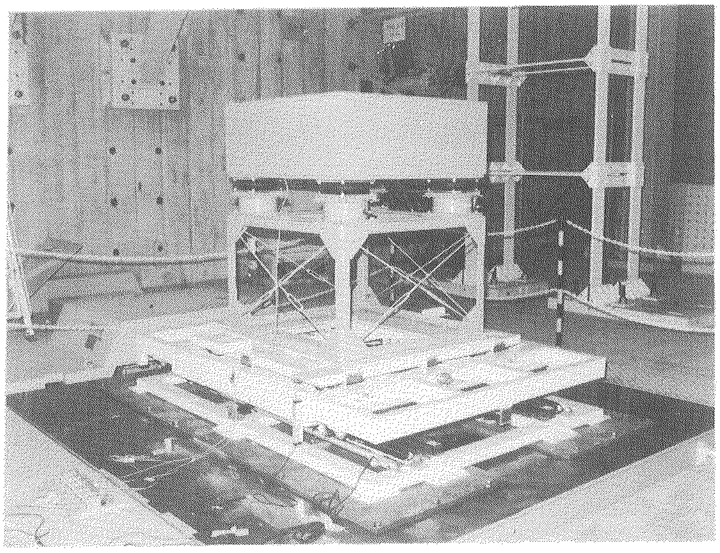

Fig.2 Three-Dimensional Earthquake Isolation Device and an Equipment Model Supported by Air Bags used in Excitation Tests.

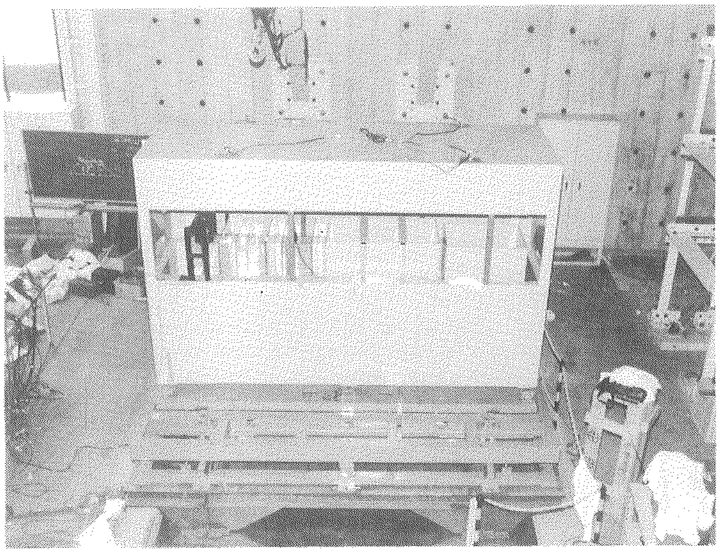

Fig.3 Full-Sized Model of Equipment Containing Glass Reservoirs of Hot Sulphuric Acid and the Three-Dimensional Isolation Device used in Excitation Tests.

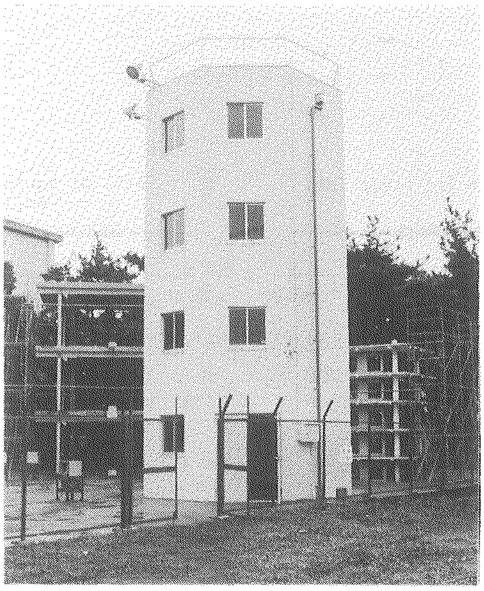

Fig.4 Four-Story Building for Response Measurement.

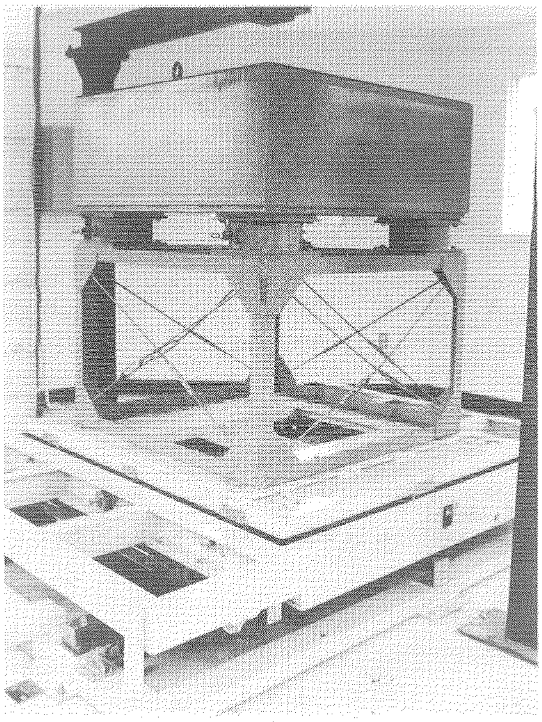

Fig.5 Three-Dimensional Earthquake Isolation Device and Equipment Model used for Response Measurement.

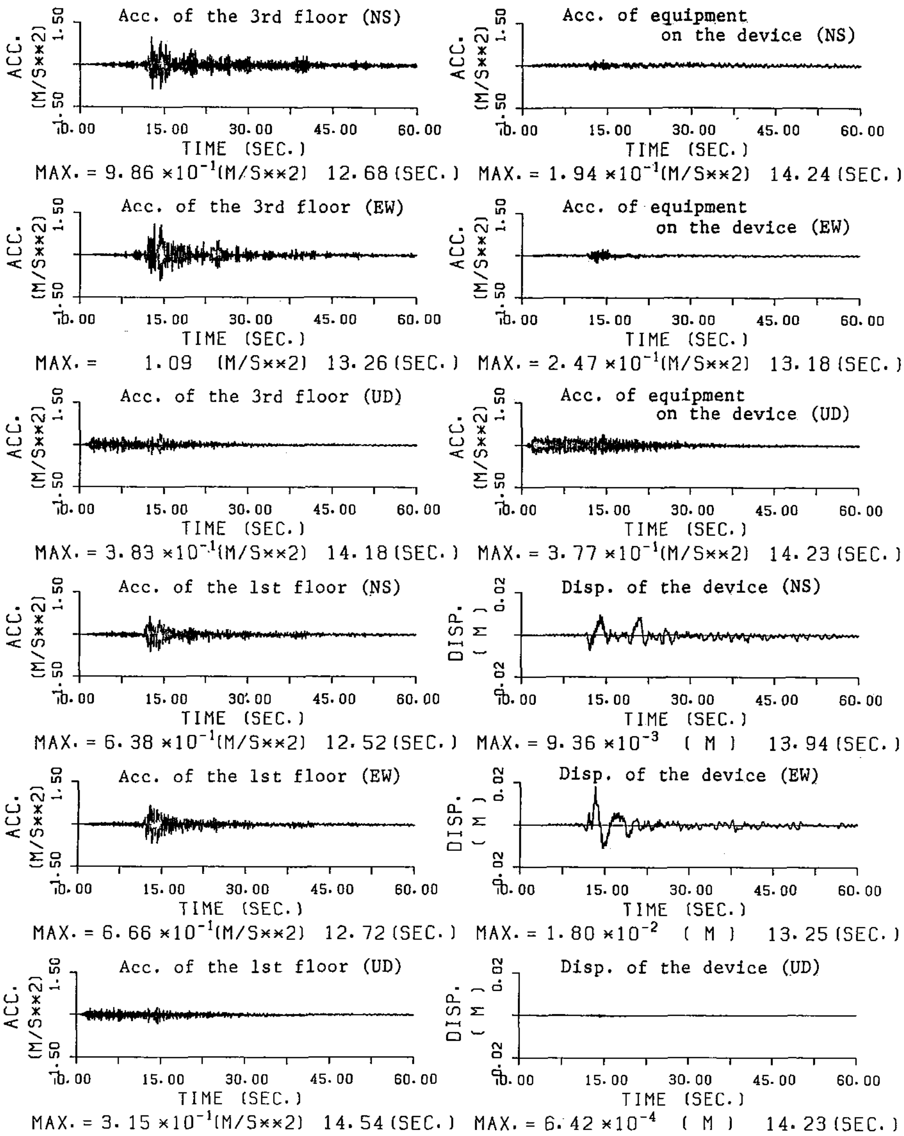

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Fig.6 An Example of measured Responses.