OBSERVATION OF A THREE-DIMENSIONAL EARTHQUAKE ISOLATION DEVICE TO NATURAL EARTHQUAKE EXCITATION

by

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SYNOPSIS

The three-dimensional earthquake isolation device used for response observation is developed as an earthquake isolation device for precision equipments such as semiconductor manufacturring facilities, and has the structure in which the equipment mounting table performs straight line motion independently in three directions in horizontal and vertical planes, and rotation in horizontal plane and rocking of mounted equipment is completely prevented.

For this device, sinusoidal excitation and earthquake excitation experiments carried out prior to response observation using a horizontal/vertical two-dimensional shaking table show good isolation effect[1]. However, the isolation effect obtained by the excitation test is that under controlled conditions of experiment. The response observation to natural earthquake is carried out for demonstrating whether specified isolation effect can be obtained or not under actual servicing conditions, and several observation results are demonstrating that the three-dimensional earthquake isolation device has sufficient isolation effect under actual servicing conditions on natural earthquake that suddenly occurs.

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RESPONSE OBSERVATION SYSTEM OF THREE-DIMENSIONAL EARTHQUAKE ISOLATION DEVICE

Figure 1 shows the response observation tower in which the three-dimensional earthquake isolation device is installed at the third floor. This response observation tower is a reinforced concrete building (with four stories above (10m) and one under (2.5m) the ground, without footing pile) having an octangular plan with 5m of distance across opposing sides. The natural period is 0.05s for the upper structure alone (fixed at the ground level) and 0.43s for the case where coupling with ground is considered[2).

The equipment model mounted on the three-dimensional earthquake isolation device is relatively rigid. Figures 3 and 4 show horizontal and vertical restoring force characteristics measured in May 2,1984. Values of major parameters are shown in Table 1.

Measurement has been carrid out on the acceleration of equipment model and that of the floor surface and on the relative displacement of earthquake isolation device with respect to the floor surface. For measuring points, accelerometers are mounted at three places (A_1,A_2,A_3) on the floor and at one place (A_4) at the center of equipment model, and the displacement meters are mounted at three places (D_1,D_2,D_3) on the earthquake isolation device, as shown in Figs.5 and 6. Since rocking response is dominant because the response observation tower is a rigid building, accelerometers A_2 and A_3 are for evaluating this effect. D_1 and D_2 are displacement meters for measuring relative displacement in two horizontal directions, and D_3 is a displacement meter for measuring relative displacement in vertical direction.

Results observed are A/D converted and recorded on magnetic tape by a data recording device.

EXAMPLE OF OBSERVED RESULTS

Since starting the observation of response to natural earthquake by using the three-dimensional earthquake isolation device, several observation results have been obtained. Among them, as an exsample for relatively intense earthquake, results observed in Feb.21,1984 and March 6,1984 are shown in Figs.7 and 8. However, in the figure, the acceleration on the third floor of observation tower is the acceleration waveform obtained by A_1 shown in Figs.5 and 6, and the relative displacement of earthquake isolation device is not shown.

The earthquake shown in Fig.7 is a near earthquake occured in small area where M=5.0 and the depth of focus is 70km, and the dominant frequency of this earthquake wave is relatively high. Although, for this input, it is generally difficult to show isolation effect since input acceleration is small for the earthquake isolation device, the horizontal acceleration of $24.1cm/s^2$ and $23.3cm/s^2$ on the floor were reduced to about 1/5 as $4.7cm/s^2$ and $4.1cm/s^2$ respectively on the equipment model, displaying sufficient isolation effect. For vertical acceleration also, the floor-surface acceleration of $11.4cm/s^2$ was reduced to about 60% as $6.7cm/s^2$ in the equipment model, this also displaying good earthquake effect.

The earthquake shown in Fig.8 is a typical remote earthquake, in which M=7.9, depth of focus is 470km and input acceleration is relatively large as about $30cm/s^2$. The dominant frequency of this earthquake is, as a feature of remote earthquake, considerably low, and is less favorable wave for the earthquake isolation device, but as shown in the figure, the acceleration was reduced to $1/4 \sim 1/5$ in horizontal direction, and to less than 80% in vertical direction, displaying isolation effect.

By these observation results, the earthquake isolation device is being demonstrated to have sufficient isolation effect on natural earthquake, and particularly, good earthquake isolation effect was demonstrated for small earthquake input that is considered to be relatively difficult to isolate.

REFERENCES

1) Fujita, T., Kuramoto, S. and Omi, T. : " A Three-Dimensional Earthquake Isolation Device ", Preprint of JSME, No.840-11, Oct.,1984, p158,(in Japanese).

2) Hangai, Y., Tatsuoka, F. and Sato, N. : " Observation of Soil-Structure Interaction of Towered Structure ", SEISAN-KENKYU, vol.35, No.9, Sept.,1983, p443,(in Japanese).

Table 1 Values of major parameters

	Movable mass	Spring constant	Natural priod
Horizontal	1573 kg	47.4 N/cm	3.62 s
Vertical	1001 kg	435.1 N/cm	0.95 s

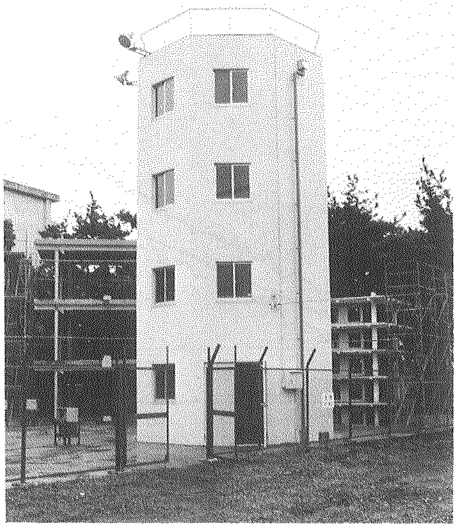


Fig.1　Response observation tower

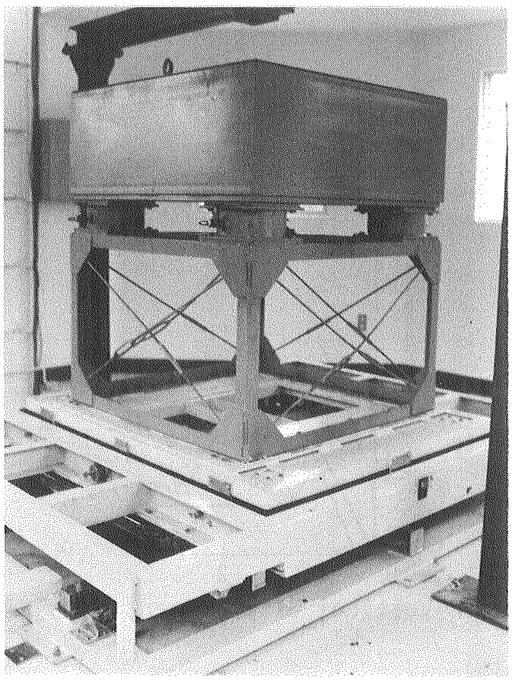


Fig.2　Three-dimensional earthquake isolation device (mounting a equipment model)

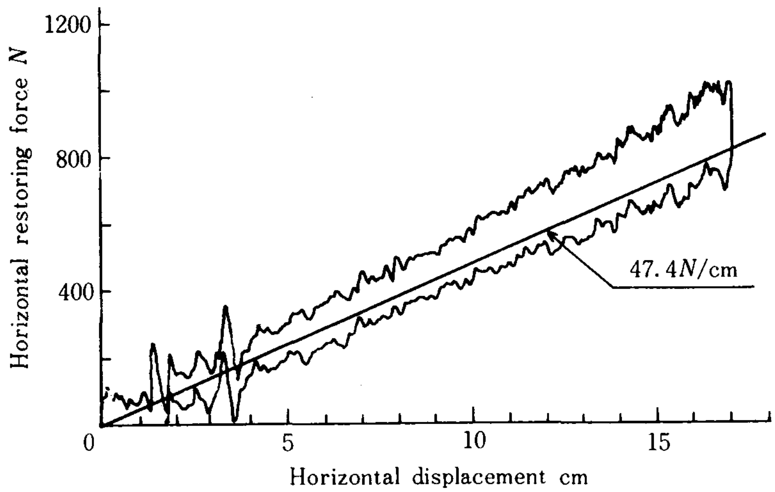


Fig.3 Horizontal restoring force characteristics

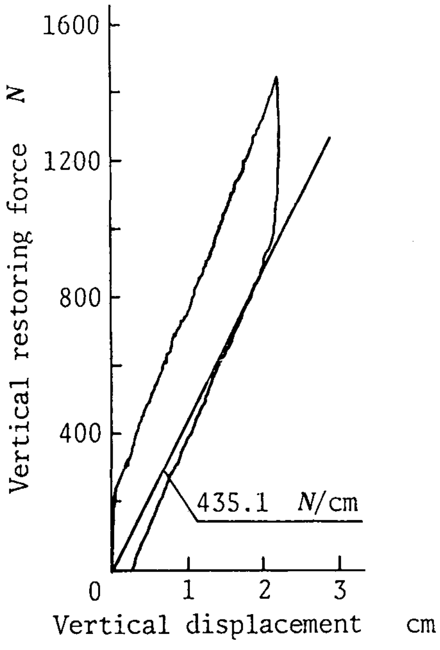


Fig.4 Vertical restoring force characteristics

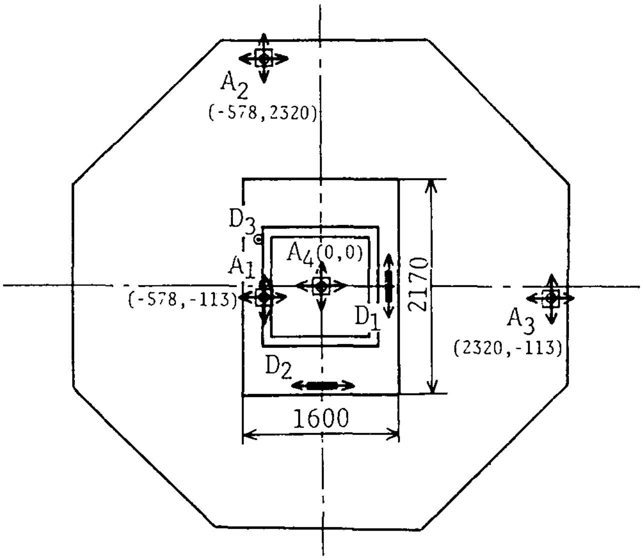


Fig.5 Placement of the device in the tower and measuring points

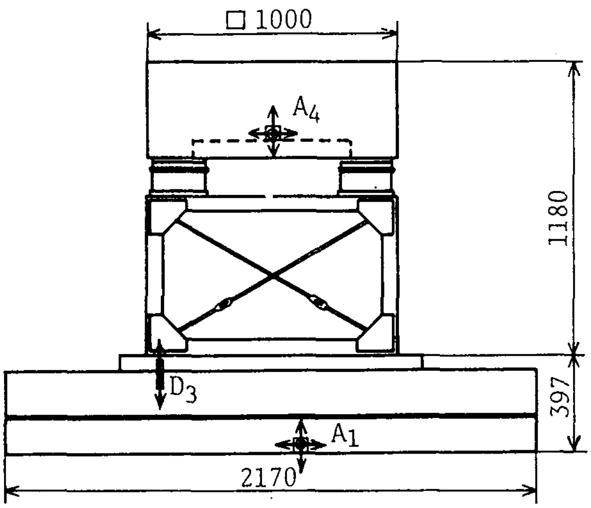
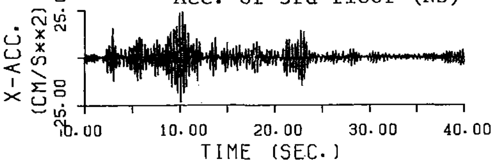


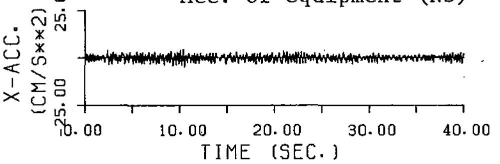
Fig.6 Arrangement of measuring points on the device

Acc. of 3rd floor (NS)



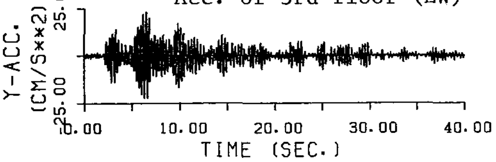
MAX. = 24.1 (CM/S**2) 10.22(SEC.)

Acc. of equipment (NS)



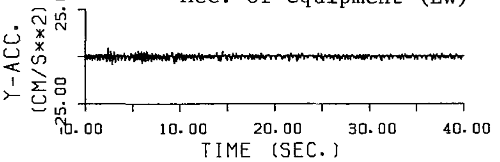
MAX. = 4.7 (CM/S**2) 10.48(SEC.)

Acc. of 3rd floor (EW)



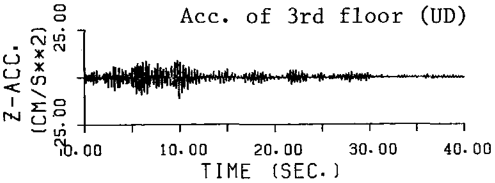
MAX. = 23.3 (CM/S**2) 6.42 (SEC.)

Acc. of equipment (EW)



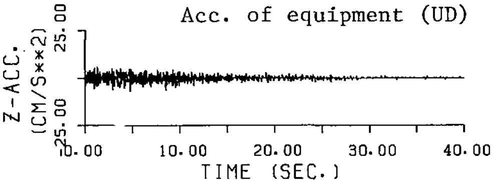
MAX. = 4.1 (CM/S**2) 2.47 (SEC.)

Acc. of 3rd floor (UD)



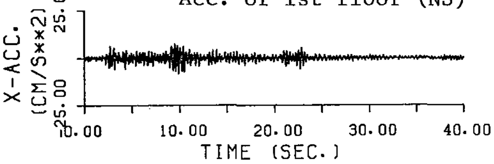
MAX. = 11.4 (CM/S**2) 9.93 (SEC.)

Acc. of equipment (UD)



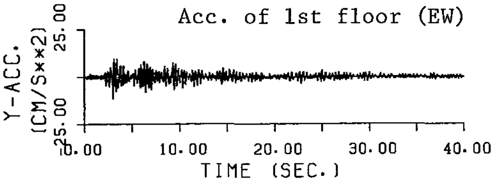
MAX. = 6.7 (CM/S**2) 4.76 (SEC.)

Acc. of 1st floor (NS)



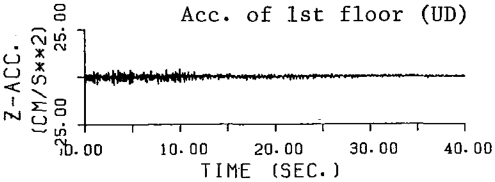
MAX. = 8.4 (CM/S**2) 9.90 (SEC.)

Acc. of 1st floor (EW)



MAX. = 11.1 (CM/S**2) 2.99 (SEC.)

Acc. of 1st floor (UD)



MAX. = 4.2 (CM/S**2) 3.04 (SEC.)

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Fig.7 Example of observation results (Part I)

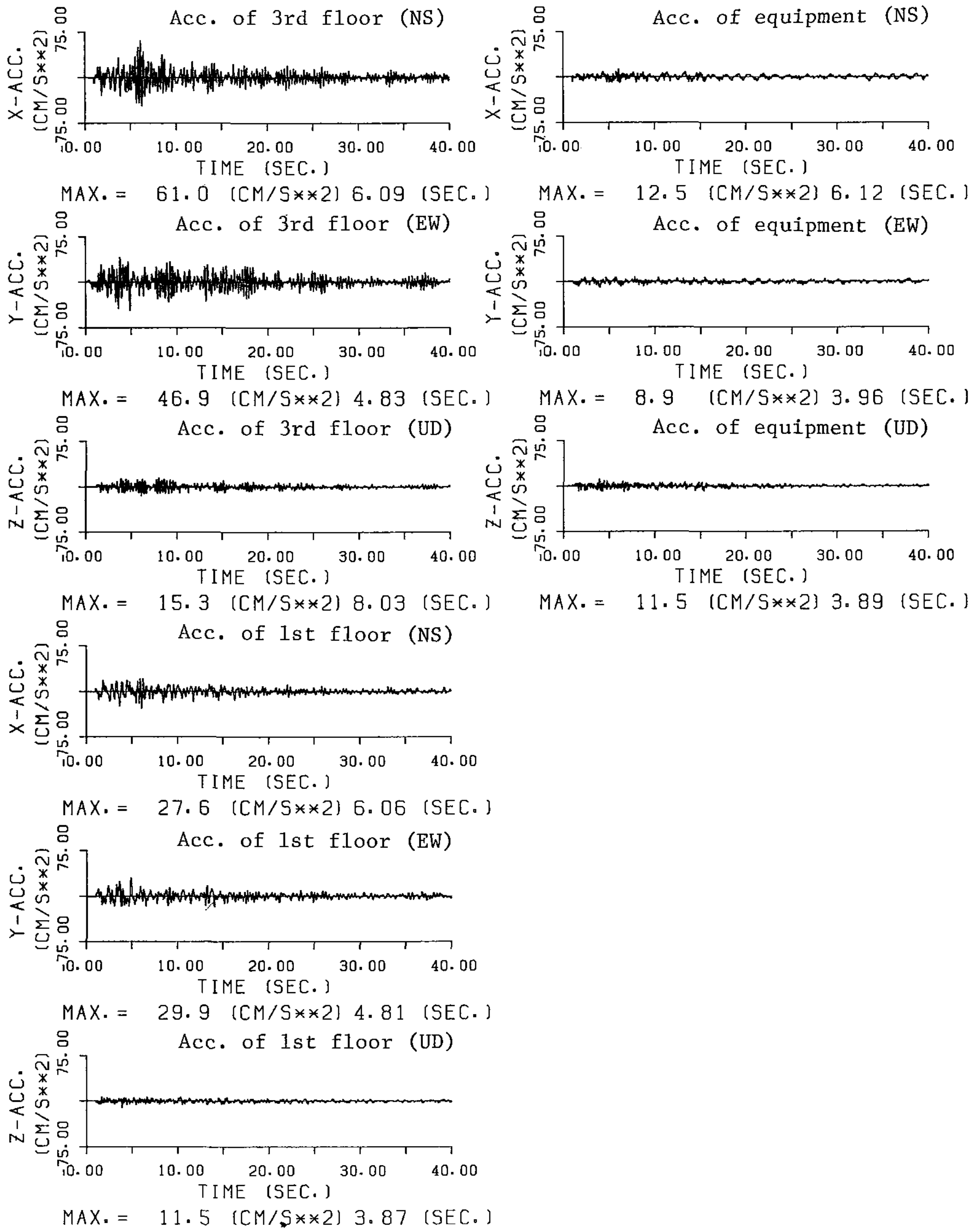

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Fig.8 Example of observation results (Part II)