Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Experimental Study on Vertical Reduction Effectiveness of Main Control Room of N.P.P using 3-Dimensional Isolation System

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1. Introduction

Main control room of nuclear power plant operates many important N.P.P facilities such as NSSS(Nuclear Steam Supply System), so it is highly recommended to secure seismic safety of main control room during and after earthquakes. A number of isolation systems installed between equipment and foundation have been widely studied[1,2]. We applied 3-D isolation systems which are consist of FPS(Friction Pendulum System), Air Spring and Damper. FPS is resistant to horizontal motion and Air Spring is resistant to vertical motion and viscous damper is resistant to rocking motion and excessive displacements.

In this study, we designed two types of main control floor systems (Type I, Type II) and a number of shaking table tests with and without 3-D isolation system were conducted to evaluate floor isolation effectiveness.

2. Shaking Table Test Procedure

2.1 structural and geometric features

Test specimen is a PCS cabinet which is installed in ULJIN 1st ,2nd main control room (Fig. 1). During shaking table test, electric parts of the cabinet are removed and the weight of PCS cabinet only is 400kgf.

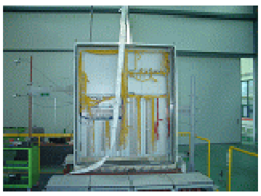


Figure 1. Cabinet

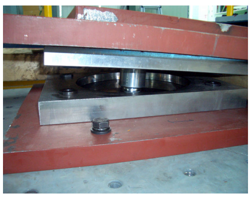


Figure 2. FPS

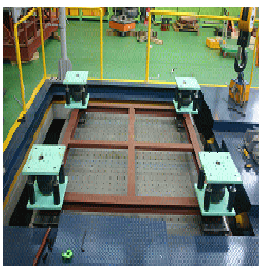


Figure 3. Air Spring

Figure 4. Damper

Four identical 3-D isolation systems were mounted beneath the bare frame model under OBE, SSE vertical input motions. The properties of 3-D isolation systems are summarized in Table 1 and Fig 2~4 show the schematic view of 3-D isolation system.

Table 1. Specification of 3-D isolation system

FPS	Natural Frequency	0.5Hz
	Radius of curvature	0.99m
Air Spring	Natural Frequency	2.0Hz
	Vertical weight capacity	700kgf/ea
Viscous Damper	Damping ratio	15%
	Damping Coefficient	15,000N·sec/m

(a) Floor system Type I (b) Floor System Type II
Figure 5. Two different types of Floor System

Fig. 5 shows two different types of floor system (Type I, Type II) which was designed to access effectiveness of seismic vibration reduction. Geometric features of two floor systems are digested in Table 2.

Table 2. Floor system dimension

Type	W × D × H (m)	Weight	Frame(mm)
Type I	2.5 × 2.5 × 0.8	2tonf	H-200×200×8×12
Type II	2.5 × 2.5 × 0.2	2tonf	H-200×200×8×12

2.2 Input motion

Fig. 6 shows floor response spectrum of OBE, SSE at 144ft and Input motions are summarized in Table 3. Note that the peak acceleration responses of vertical earthquake motion are distributed about 15-16 Hz frequency range.

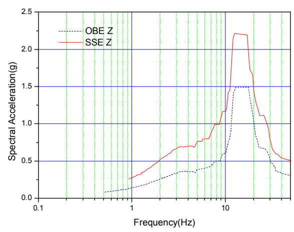


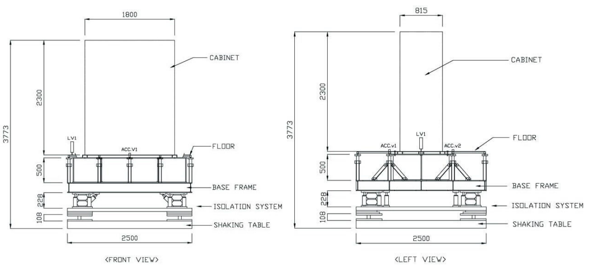
Figure 6. Input motion

Table 3. Input Motion

Input Motion	Duration(sec)	ZPA(g)	Remarks
OBE Vertical	80.0	0.389	144ft, 5% damp
SSE Vertical	80.0	0.734	144ft, 5% damp

2.3 Shaking Table Tests

In order to acquire the response of the cabinet, 2 vertical ones were attached on the both sides(left, right) of the cabinet bottom (Fig. 7)



(a) Front View (b) Side View

Figure. 7 External Accelerometer schematic View

3. Test Results and discussion

3.1 Acceleration Comparison

The measured maximum floor accelerations for bare frame and isolated model under vertical strong ground motions are presented in Table 4. With the provision of 3-D Isolation system, a significant reduction effect was seen under OBE & SSE vertical motion.

Table 4. Maximum floor acceleration

Input Motion (Max. Acc, g)		Left			Right		
		W/O	With	R.R (%)	W/O	With	R.R (%)
OBE Vert. (0.389)	Type I	0.474	0.165	65	0.448	0.171	62
	Type II	0.488	0.139	72	0.466	0.156	67
SSE Vert. (0.734)	Type I	0.786	0.179	77	0.775	0.165	79
	Type II	0.763	0.278	63	0.748	0.262	65

Fig. 8 shows maximum vertical response reduction ratio of the cabinet. As it was seen in Table 4, there was about 50% seismic reduction effect in OBE & SSE vertical motion and a little difference between Type I and Type II as well as between left side and right side.

Where Max. reduction ratio = $\dfrac{\textit{Acquired Cabinet GPA}}{\textit{Input GPA}}$

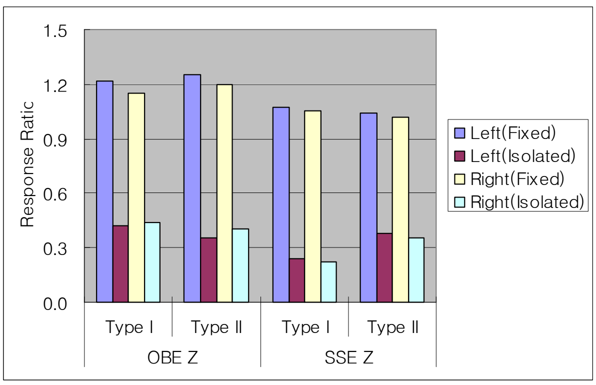
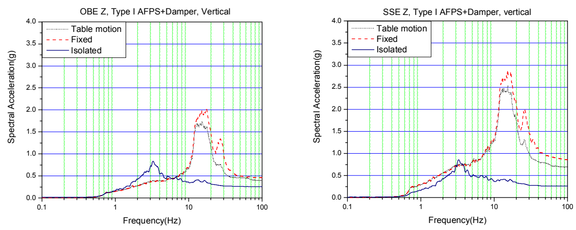


Figure. 8 Max. response reduction ratio

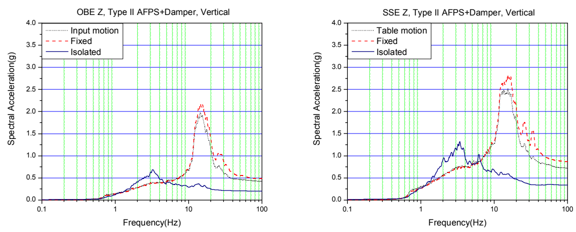
3.2 Response Spectrum

Acceleration response spectra at the bottom of the cabinet are presented in Fig. 9~10. Large acceleration reduction effect was seen in both OBE, SSE and there was an obvious predominant frequency drift(3.0Hz) to the air spring natural frequency(2.0Hz).



(a) OBE (b) SSE

Figure 9. Acceleration Response Spectrum (Type I, bottom)



(a) OBE (b) SSE

Figure 10. Acceleration Response Spectrum (Type II, bottom)

4. Conclusion

To evaluate vertical floor isolation effectiveness of 3-D isolation system, several seismic shaking table tests with and without isolation system were conducted. As a result of tests, both types have showed large vertical reduction effect according to input earthquake signals. Also there was an obvious predominant frequency drift effect to the vertical isolation natural frequency in vertical direction.

ACKNOWLEDGEMENT

This research was financially supported by Ministry of Commerce, Industry and Energy and Korea Electric Power Research Institute and the authors are grateful to the authorities for their support.

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