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Experimental Study on the ICRS Amplification of Electrical Cabinet

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1. Introduction

Recent earthquake occurred in Korea shows high frequency ground motion characteristics. In this study the high frequency ground motion effect on the in-cabinet response of electrical components in a nuclear power plants. The ICRS is a demand response spectrum for a device installed in a cabinet. A shaking table tests were performed to estimate the seismic response of the electrical cabinet. Based on the test results, the in-cabinet amplification was estimated for different earthquake input motions.

2. Test Model of Electrical Cabinet

Figure 1 shows the electrical cabinet for the shaking table test. The total weight of the cabinet is 549 kg, and the dimension of the cabinet is 1,200x600x2,450 mm. Figure 2 shows the dimension of the cabinet and internal structure.

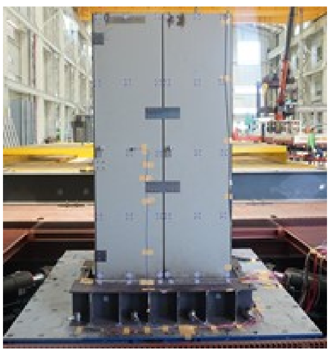

Fig. 1. Test Model of Electrical Cabinet for Shaking Table Tests.

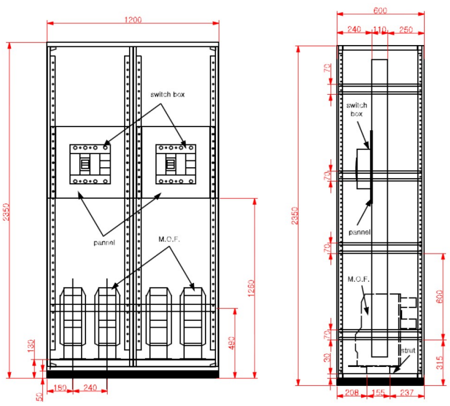

Fig. 2. Dimension of the Test Cabinet..

3. Shaking Table Tests

3.1. Test Setup

As shown in Figure 3, the test cabinet is installed on the jig which is to fix the cabinet to the shaking table. The cabinet is welded to the jig, and the jig is fixed to the table by bolts. Six accelerometers (A1-A6) were installed to measure the acceleration response of the cabinet. Two accelerometer (A5 and A6) were installed outside of the cabinet to measure the global response of the cabinet. And two accelerometers (A3 and A4) were installed inside of the cabinet to measure the local response of the panel which is installed to attach a device. A1 and A2 are installed on the table and on the top of the jig.

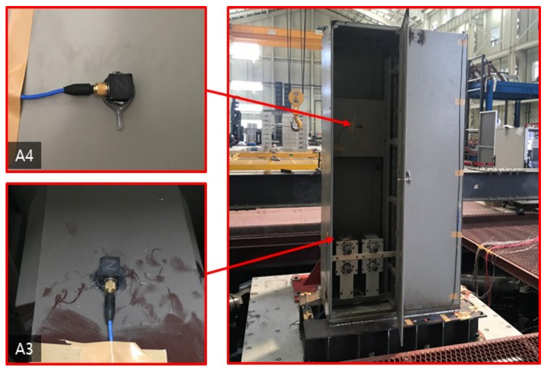

Fig. 3. Location of the Sensor for Acceleration Measurement inside of the Cabinet.

In the test, two kinds of input response spectrum, standard response spectrum proposed by US NRC [1] and UHS (Uniform Hazard Spectrum) for a nuclear power plant site [2]. Figure 4 shows the comparison of the two different response spectrum shape.

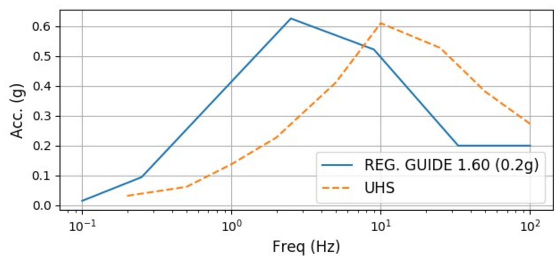

Fig. 4. Input Ground Motion Response Spectrum for Shaking Table Tests (Horizontal Direction).

3.2. Resonance Test

To estimate the dynamic characteristics of the test cabinet, the resonance tests were performed before the test. And the resonance tests were performed after the tests to check the change of the dynamic characteristics by the aging effect from the repeated tests. The fundamental frequency of the cabinet is 15Hz and 20.5Hz in the side-to-side direction and front-to-back direction, respectively.

3.3. Test Procedure

Table 1 shows the test procedures. Before the earthquake motion test, first resonance test was performed for three directions. Shaking table test was performed for four different input motions with multi-axis time history. After the test, resonance test was performed to check the change of the dynamic characteristics of the cabinet.

Table I: Shaking Table Test Procedures.

Step	Test	Input	Direction
1	Resonance Test	Sine sweep	x
2	“	“	y
3	“	“	z
4	Multi-axis earthquake test	RG-G*	x/y/z
5	“	RG-A**	“
6	“	UHS-G	“
7	“	UHS-A	“
8	Resonance Test	Sine sweep	x
9	“	“	y
10	“	“	z

*RG-G : Regulatory Guide 1.60-Ground
**RG-A : Regulatory Guide 1.60-Aux. Bldg

4. Shaking Table Test Results

4.1. Test Results

The measured acceleration response at the inside of the cabinet is compared with the acceleration response spectrum on the top of the shaking table.

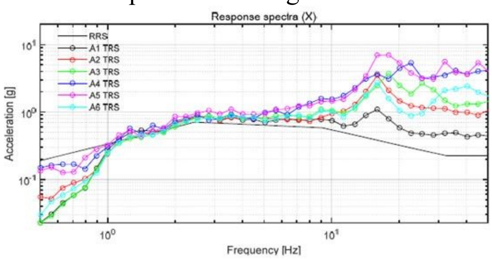

Fig. 5. Measured Acceleration Response Spectrum of Inside and Outside of the Cabinet.

4.2. Cabinet Amplification

The in-Cabinet amplification factor is estimated based on the maximum spectral acceleration of demand response spectrum and that of the ICRS (In-Cabinet Response Spectrum) [3].

$$AF_g = \frac{S_{a1}(f_{x1}, 5\%)}{S_{a0}(f_{x0}, 5\%)} \quad (1)$$

Where $S_{a0}(f,\xi)$ is the maximum spectral acceleration of the base response spectrum which is input to the cabinet base, f is frequency and ξ is damping ratio. $S_{a1}(f,\xi)$ is maximum spectral acceleration of the ICRS (In-Cabinet Response Spectrum) at the device location. f_{x0} is the frequency at the maximum of S_{a0}, and f_{x1} is the frequency at the maximum of S_{a1}.

Table II shows the maximum spectral acceleration measured at A1 and A4, and corresponding amplification factor. As shown in this table, amplification factors for the high frequency ground motion is larger. The amplification factor for cabinets installed on the floor in a building shows larger than that for cabinets installed on the ground.

Table II: Measured Maximum Spectral Accelerations and Cabinet Amplification Factors.

Input Motion	S_{a0}(g)	S_{a1}(g)	AF_g
RG-G	3.47	5.35	1.54
RG-A	5.41	17.86	3.30
UHS-G	3.15	16.40	5.21
UHS-A	4.26	36.43	8.54

5. Conclusions

In this study, a shaking table test for an electrical cabinet was performed to estimate the acceleration amplification of the cabinet. Test results show that the amplification factor is different according to the base input motion. And the amplification at a panel installed in the cabinet is larger than that of the global response measured at the outside frame of the cabinet.

Acknowledgment

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