Effects of a Seismic Isolation for an Offsite Transformer on its Seismic Capacity and Core Damage Frequency

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1. Introduction

In this study, a seismic isolation system is adopted to an offsite transformer for a decrease of the core damage frequency (CDF). The Offsite Transformer is a major equipment of the Offsite Power system. Most of the equipments including the offsite power system have a weak fragility for an earthquake. Especially the bushings are very weak for a seismic event. If the switch yard systems are failed for the earthquake, it will make the nuclear reactor and turbines stop. Therefore in this study, an offsite transformer, which can be isolated, is selected for isolation. For the isolation system, the friction pendulum system was adopted. As a result, the seismic forces decreased by 69% and the CDF is 13.9% by using the FPS.

2. Offsite Transformer

2.1 Dimension of the Offsite Transformer

It is very difficult to isolate the offsite power system. One of the equipments in the offsite power which is possible for isolation is the offsite transformer. The offsite transformer is located in a field near the containment building. The figure of the offsite transformer is shown in Figure 1. In this study, for the verification of the effectiveness of the isolation system, a numerical analysis was performed. For the numerical analysis, the dimension of the transformer of the Younggwang 5 unit was used. The dimension of the model transformer is shown in Table 1.

Figure 1. Offsite Transformer (Younggwang 5 unit)

Table 1. Dimension of Transformer

Whole Dimension	Width	6,980 mm
	Length	5,075 mm
	Height	8,055 mm
Shipping Dimension	Width	5,315 mm
	Length	3,340 mm
	Height	6,450 mm
Weight	Shipping Weight	145 tonf
	Oil weight	28 tonf
	Whole Weight	186 tonf

2.2 Numerical Modeling of Offsite Transformer

For the numerical analysis, the commercial computer program SAP2000 [1] is used. The numerical model is constructed as a single degree of freedom. The natural frequency of the transformer is almost 15Hz [2], so the behavior of the isolated transformer is almost a rigid body.

2.3 Isolation System

For the isolation of the transformer, the FPS system is used. As shown in Table 1, the weight of the transformer is actually not enough for the rubber bearing system. Therefore the FPS system is appropriate for the isolation of the transformer. As shown in Table 2, two kinds of FPS systems are used for the analysis. The two kinds of systems are selected by the target frequency.

Table 2. Properties of FPS

Target Frequency	Radius of Curvature
0.5Hz	0.99m
0.33Hz	2.33m

In the numerical analysis, the friction coefficient is changed as shown in Table 3. For the seismic response analysis, the US NRC 1.60 [3] design earthquake is used. The PGA used is 0.2g and 0.3g.

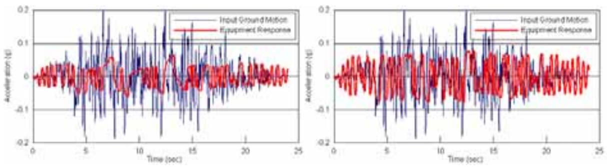
Table 3. Friction Coefficient of FPS

	Fmin	Fmax
Low	0.03	0.06
Medium	0.06	0.10
High	0.08	0.15

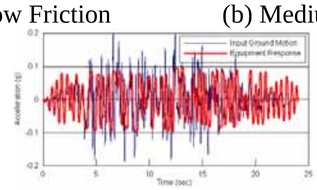
3. Analysis Result

3.1 Analysis Results

In Figure 2, some of the acceleration responses are shown as a friction coefficient. As shown in Figure 2, the acceleration responses are remarkably affected by the friction coefficient. In Figure 3, the response spectrum and the force-displacement hysteresis are shown. As shown in Figures 2 and 3, a lesser friction coefficient of the FPS causes more seismic forces to decrease.

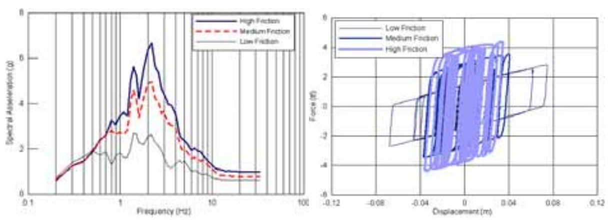


(a) Low Friction (b) Medium Friction



(c) High Friction

Figure 2. Acceleration Response of the Isolated Transformer as the Friction Coefficient (PGA=0.2g, Target Frequency=0.5Hz)



(a) Response Spectrum (b) Histeresys

Figure 3. Analysis Results (PGA=0.2g, Target Frequency=0.33Hz)

3.2 Decrease of the Core Damage Frequency

The decrease of the CDF is investigated as decrease of the seismic forces by using the isolation system. In Figure 4, the decrease of CDF as a decrease of the seismic force is shown. As shown in Figure 4, only the loss of the offsite power event (LOOP) can affect the CDF. Based on the Figure 4, the decrements of the CDF are summarized in Table 4. As shown in Table 4, in the case of 0.2g, the maximum decrement of the seismic force is 63% and that of the CDF is 13.4%. In the case of 0.3g, the maximum decrement of the seismic force is 69% and that of the CDF is 13.9%. As a result, only an isolation system adopted to the offsite transformer can effectively decrease the CDF.

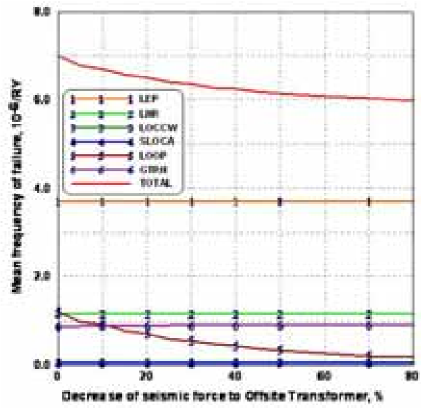


Figure 4. Decrease of CDF as Isolation

Table 4. Decrease of Seismic Forces and CDF

PGA	Target Frequency	Friction Coefficient	Decrease of Seismic Force	Decrease of CDF
0.2g	0.5Hz	Low	56%	12.6%
		Medium	43%	11.7%
		High	28%	9.2%
	0.33Hz	Low	**63%**	**13.4%**
		Medium	46%	11.7%
		High	29%	9.2%
0.3g	0.5Hz	Low	60%	13.1%
		Medium	53%	12.3%
		High	43%	11.7%
	0.33Hz	Low	**69%**	**13.9%**
		Medium	60%	13.1%
		High	46%	11.7%

4. Conclusion

In this study, a seismic isolation system is adopted to an offsite transformer for a decrease of the core damage frequency (CDF). For the isolation system, the friction pendulum system was selected. As a result, the FPS can successfully decrease the seismic force by 69% and the CDF is 13.9%.

ACKNOWLEDGEMENT

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