Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 25-26, 2012

Performance Evaluation of Interface Piping System for Seismically Isolated NPPs

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1. Introduction

Recently, to design the nuclear power plants (NPPs) more efficiently and safely against the strong seismic load, many researchers focus on the seismic isolation system. For the adoption of seismic isolation system to the NPPs, the seismic performance of isolation devices, structures, and components should be guaranteed firstly. Hence, some researches were performed to determine the seismic performance of such items [1,2]. In the viewpoint of the components and equipment, most of them will gain the improved seismic performance due to the installation of isolation devices. However, for the interface piping system between isolated structure and non-isolated structure, the seismic capacity should be carefully estimated since that the required displacement absorption capacity will be increased significantly by the adoption of the seismic isolation system. In this study, we performed the preliminary seismic performance evaluation of interface piping system for seismically isolated NPPs. The detailed procedure and main results are summarized in next section.

2. Methods and Results

2.1 Required Displacement Absorption Capacity

To estimate the seismic performance of interface piping system, firstly, we estimated the required displacement absorption capacity for isolated NPPs. Fig. 1 depicts the auxiliary building structure of APR1400 NPP.

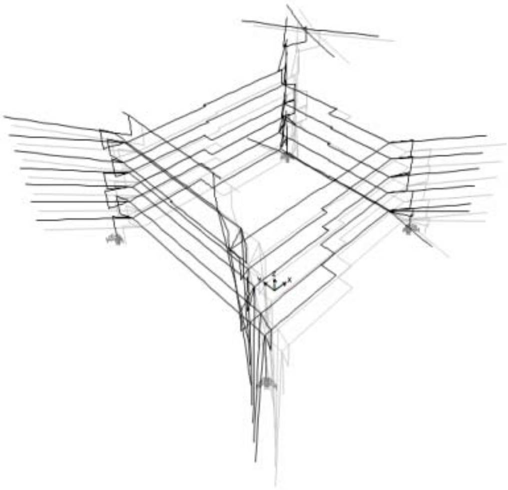

Fig. 1. Modeling of auxiliary building structure.

The seismic performance of structural system will be varied by the frequency contents and intensities of earthquake ground motion. In this study, we considered 4 representative earthquake ground motions. In Fig. 2, acceleration response spectra normalized by 0.2g are illustrated. From the NRC and UHS response spectra, we generated spectra-compatible artificial acceleration time histories.

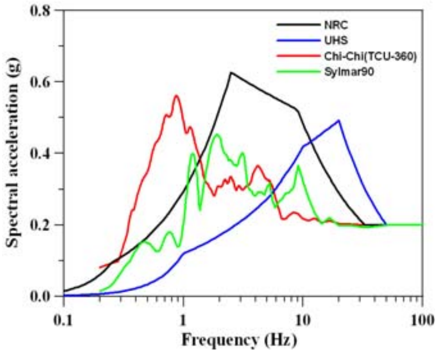

Fig. 2. Acceleration response spectra for each earthquake (normalized by 0.2g).

With respect to the each ground motion, we estimated the required displacement absorption capacity for interface piping system as listed in Table I. We assumed that the piping system and their main structures were uncoupled. Comparing the results with the acceleration response spectra in Fig. 1, it can be found that the required displacement absorption capacity increases significantly as the low frequency contents of input ground motion increases. Even the same ground motion intensity in PGA, it can be easily seen that the required capacity of Chi-Chi earthquake is larger than that of UHS compatible earthquake by 7.5 times for 0.2g ground motion scale, and 13.5 times for 0.5g ground motion scale. This tendency becomes more severe for the strong ground motion intensity since that the nonlinear behavior of piping system is occurred when the strong ground motion attacked.

Table I: Required displacement absorption capacity with respect to the variation of input ground motions.

Earthquake	*Required Capacity (mm)*	
	0.2g	0.5g
NRC	59.1	161.8
UHS	25.8	42.6
Chi-Chi	196.5	569.9
Sylmar90	53.3	179.3

2.2 Performance Evaluation Results

Fig. 3 depicts the iso-drawing and pictures of target interface piping system. We assumed that one end of it is attached at the non-isolated turbine building, and another end of it is fixed at the isolated auxiliary building. Fig. 4 & 5 represent the maximum stress response of interface piping system for 0.2g and 0.5g input ground motions, respectively.

For all ground motions, the maximum stress increases considerably by using the isolation systems. However, for 0.2g scaled earthquakes, the most of the maximum stress responses stay under the design-level limit stress, 350MPa except for the Chi-Chi earthquake which include the low frequency contents significantly. On the other hand, for 0.5g scaled earthquakes, we can found that all of the maximum stress responses exceed the design-level limit stress. In that case, it can be conclude that additional activity to reduce the stress response so that guarantee the safety & healthiness of interface piping system should be required.

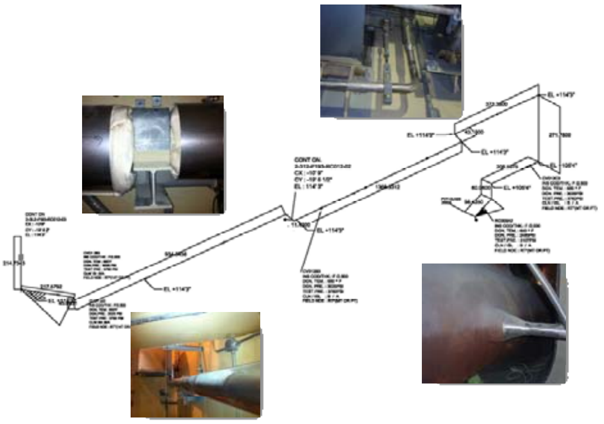

Fig. 3. Iso-drawing and pictures of the target piping system.

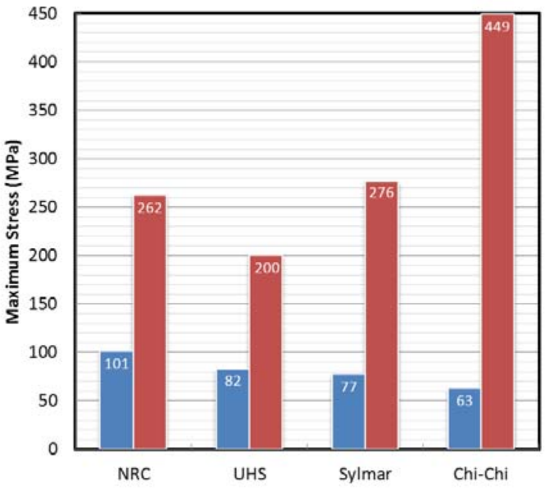

Fig. 4. Maximum stress response of interface piping system (0.2g).

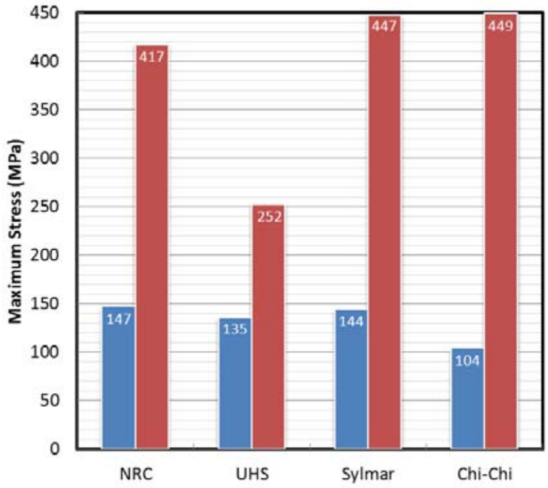

Fig. 5. Maximum stress response of interface piping system (0.5g).

3. Conclusions

For the interface piping system between isolated structure and non-isolated structure, the seismic capacity should be carefully estimated since that the required displacement absorption capacity will be increased significantly by the adoption of the seismic isolation system. In this study, we performed the preliminary seismic performance evaluation of interface piping system for seismically isolated NPPs. For 0.5g scaled earthquakes, it can be found that all of the maximum stress responses exceed the design-level limit stress. In that case, we conclude that additional activity to reduce the stress response so that guarantee the safety & healthiness of interface piping system should be required. However, for more reliable results and decisions, more detailed & realistic model for piping systems and structures will be required.

Acknowledgement

This work was supported by the Energy Research & Development of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Knowledge Economy.

REFERENCES

[1] M.K. Kim, J.H. Kim, and I.-K. Choi, Investigation of Performance Objectives for Seismic Isolation Systems of Nuclear Power Plants, Technical Report, Korea Atomic Energy Research Institute, 2012.

[2] D. Hahm, J. Park, and I.-K. Choi, A Review of Performance Criteria and a Preliminary Performance Evaluation Analysis of Piping System for Seismically Isolated Nuclear Power Plant, Technical Report, Korea Atomic Energy Research Institute, 2012.