Application of Seismic Isolator to a Pool Cover in Research Reactor

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1. Introduction

Recent studies have revealed that the use of base isolation devices can increase the seismic resistance of nuclear facilities [1]. So, this paper deals with an application of the seismic isolator to the pool cover in the research reactor in order to enhance a seismic resistance capacity. The seismic resistance in a way of seismic isolators is increased [2] by shifting the fundamental frequency of the pool cover away from the dominant frequency of the design floor response spectrum loads at the installing position. For this purpose, 3-D finite element models are developed by two cases; without seismic isolators and with seismic isolators and their dynamic characteristics are analyzed. Seismic analyses of the pool cover subjected to the designed floor response spectra loads of SSE (Safe Shutdown Earthquake) are performed. Then, through performance comparison between the pool cover without and with seismic isolators under seismic loads, the effect of seismic isolation in the pool cover is thoroughly investigated.

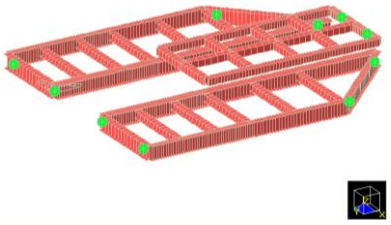
2. Design of Pool Cover and Seismic Isolator

The pool cover is designed to protect the reactor from foreign materials and to support the irradiation object handling devices in the research reactor [3]. It consists of PC-A, PC-B and sliding panel which are covered with grating plates and cover plates. It also has hooks, lugs, and various tools for handling fuels and irradiated objects.

Seismic isolators applied to the pool cover in this paper are multi-directional seismic isolation devices such as energy dissipate system or spring-viscous damper system [1].

3. Modeling of Pool Cover

The 3-D finite element models of the pool cover are developed by utilizing MIDAS CIVIL program. All parts of the pool cover are modeled as beam elements, distributed masses and point masses. The weights of structural members are considered as the distributed masses. The weights of non structural members are modeled as the point masses on the nodes of the beam elements. In case of seismic isolators applied to the pool cover, nonlinear link elements are used. Established finite element models and boundary conditions of the pool cover in two cases; without seismic isolators and with seismic isolators are shown in Fig. 1. Materials used for most parts of the pool cover are stainless steel 304L.



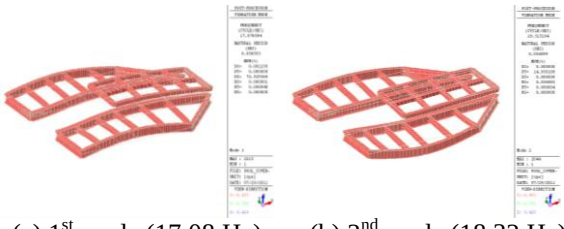
(a) Case without seismic isolators

(b) Case with seismic isolators

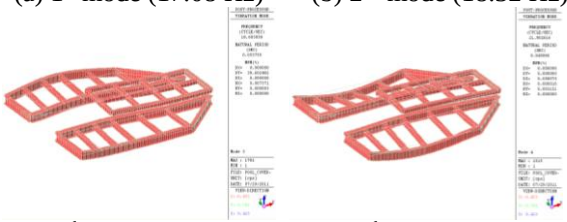
Fig. 1 3-D finite element models of the pool cover

4. Modal Analysis

In order to investigate the dynamic characteristics of the pool cover without and with seismic isolators, modal analyses of the developed finite element models are performed. The typical measures of the dynamic characteristics about two cases, natural frequencies and mode shapes, are obtained. Fig. 2 and 3 show four mode shapes of two cases, respectively. These indicate that the pool cover with seismic isolators in Fig. 3 represents the isolated modes in x, y and z direction from 1st to 4th mode in comparison with Fig. 2.

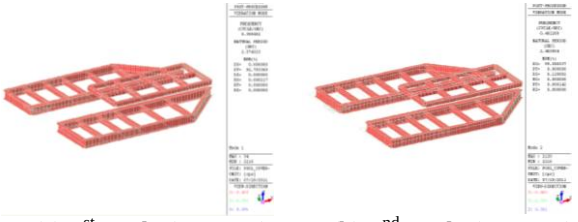


(a) 1st mode (17.08 Hz) (b) 2nd mode (18.32 Hz)

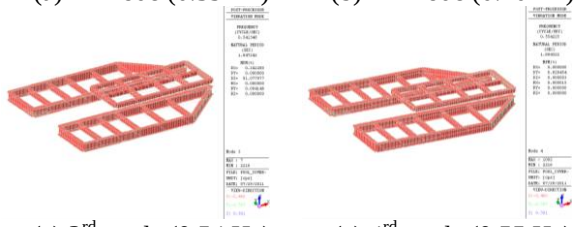


(c) 3rd mode (18.60 Hz) (c) 4rd mode (21.80 Hz)

Fig. 2 Natural frequencies and mode shapes of the pool cover without seismic isolators



(a) 1st mode (0.39 Hz) (b) 2nd mode (0.40 Hz)



(c) 3rd mode (0.54 Hz) (c) 4rd mode (0.55 Hz)

Fig. 3 Natural frequencies and mode shapes of the pool cover with seismic isolators

5. Seismic Analysis of Pool Cover

The seismic response analysis of the pool cover uses response spectrum method which is widely employed in the seismic design of structures as it reduces the computational cost compared with other methods. Total 100 modes are considered for the modal response combination to take into account a modal effective mass of 90% of the model, and the square root of the sum of the squares (SRSS) method is used to combine total response in each mode and direction.

5.1 Dead, Live and Seismic Loads

The weight of all components constituting the pool cover and equipments for the related operation is about 1800kg. This is considered as a dead load. Live load is assumed to be 500kg/m^2. Finally, the seismic load inputs are used as the enveloped floor response spectra for SSE at the installing position of the pool cover as shown in Fig. 4. The 7% damping is used for the horizontal and vertical floor response spectra.

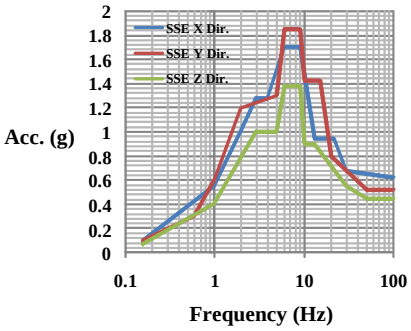


Fig 4 Floor response spectra for SSE (0.3g)

5.2 Properties of Seismic Isolator

A helical spring-viscous damper is used as a seismic isolator in this study. Horizontal and vertical effective stiffness are 5 N/mm and 10 N/mm, respectively. The viscous damping ratio is 0.2 ~ 0.3.

5.3 Seismic Analysis Results

As a result, as shown in Fig. 5, maximum beam stress in the pool cover without seismic isolators under seismic load is 45.37MPa. On the other hand, maximum beam stress in the pool cover with seismic isolators represented in Fig. 6 is 25.50MPa. These indicate that through application of seismic isolators, seismic resistant capacity of the pool cover has been raised by more than 75 percent.

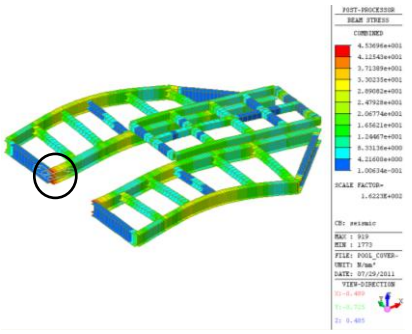


Fig. 5 Beam stress results about pool cover without seismic isolators

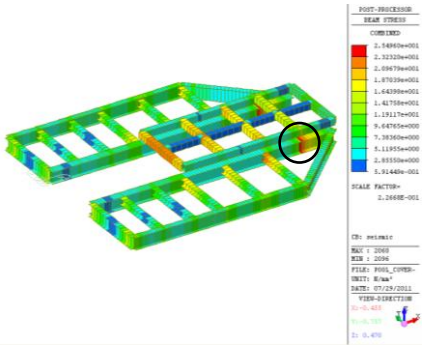


Fig. 6 Beam stress results about pool cover with seismic isolators

6. Conclusion

Seismic isolators have been applied to the pool cover of the research reactor in this study. In order to compare the performances between the pool cover without and with seismic isolators under seismic load, modal and seismic analyses were performed. As a result, it was demonstrated that the seismic resistant capacity of the pool cover had been increased through adopting seismic isolators.

REFERENCES

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[3] Jeong-Soo Ryu et al., “Design of Pool-Cover for Increasing HANARO Application”, Proceedings of 2001 spring KNS, 2001.