Determination of a Simplified Analysis Model of Spent Fuel Storage Rack for Seismic Analysis

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1. Introduction

A whole-pool-multi-racks (WPMR) model which simulates whole racks stored in the spent fuel pool to consider the impacts between racks and rack-to-pool is used for a seismic analysis of a stent fuel storage rack[1]. A simplified model of a stent fuel storage rack is determined to simulate a movement of racks and an impact between racks or rack-to-pool. In this paper, the method to determine a simplified model of a spent fuel storage rack for seismic analysis is studied. A simplified model is determined to simulate the dynamic behavior of a spent fuel storage rack. To determine a simplified model of a spent fuel storage rack, the detailed finite element analysis is conducted.

2. Detailed model of rack

The 9 X 10 spent fuel storage rack is modeled as shown in Fig. 1. The welding between cells is considered. To consider a dynamic behavior, the modal analysis is conducted. Fig. 2 shows an x-direction and a y-direction displacement of a detailed model at the first and third modes, respectively. The first and third modes show the bending mode of rack. Deformations of the other modes show the distortion mode as shown in Fig. 3.

Fig. 1. Detailed model of rack.

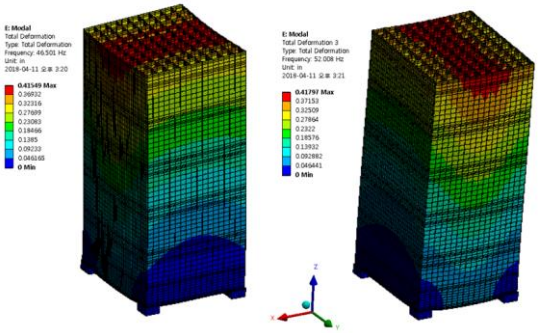


Fig. 2. The 1st and 3rd mode shape of a detailed model.

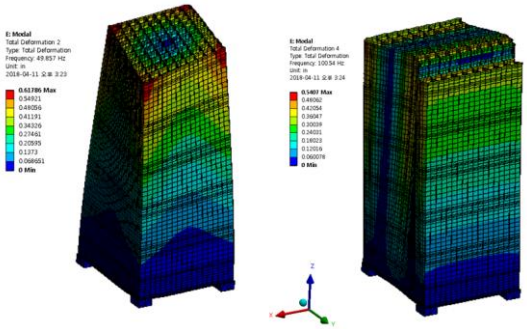
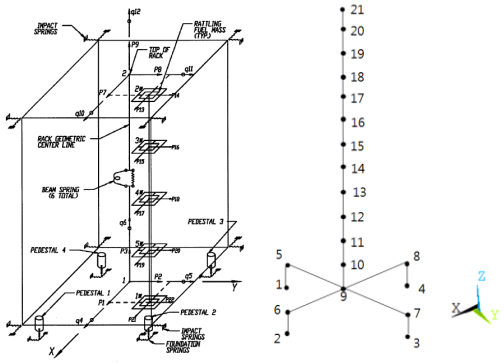


Fig. 3. The 2nd and 4th mode shape of detailed model.

3. Simplified model of rack

Fig. 4 shows the schematic model of a simplified rack model. Fig. 4(a) shows the sample of a seismic

rack model[2]. The simplified model as shown in Fig. 4(b) is simulated for a seismic rack model. A rack is simulated by a mass-beam model as parts of a cell, bottom plate and reg. The bottom plate is modeled as a rigid body by using a large flexural rigidity because all bottom plate is welded with a cell. A flexural rigidity of rack leg can be determined as a geometric shape. A flexural rigidity of rack cell which considers the welding effect needs to be determined.



(a) Seismic rack model[2] (b) simplified model

Fig. 4. Simplified model of a rack.

A simplified model can simulate the directional behavior of a spent fuel storage rack as shown in Fig. 2 so a flexural rigidity of rack cell is determined which has the same natural frequency as that of detailed model. The first and third modes are the major mode to simulate the impact between racks and rack-to-pool.

A flexural rigidity of a rack cell has a directional value. The ratio of a flexural rigidity in an x-direction to that in a y-direction is determined by a theoretical ratio considering geometry. Table 1 shows the natural frequencies of a simplified and a detailed model. The first and the second natural frequencies of a simplified model are similar with the first and the third natural frequencies of a detailed model.

Table 1. Natural frequency of rack

	1st	2nd	3rd	4th
Detailed model	46.501	49.857	52.008	100.54
Simplified model	46.603	50.443	216.55	239.64

4. Conclusion

The method to determine a simplified model of rack for a seismic analysis of a spent fuel storage rack is studied. A rack is simulated by a mass-beam model as parts of a cell, bottom plate and reg. A flexural rigidity of rack cell is determined which has the same natural frequency as that of detailed model. The major modes to simulate the impact between racks and rack-to-pool are only considered. The ratio of a flexural rigidity in an x-direction to that in a y-direction is determined by a theoretical ratio considering geometry.

REFERENCES

[1] G. DeGrassi, “Review of the Technical Basis and Verification of Current Analysis Methods Used to Predict Seismic Response of Spent Fuel Storage Racks”, NUREG/CR-5912(BNL-NUREG-52335) (1992).

[2] Holtec Report, “Licensing report for South Texas Project units 3&4 ABWR spent fuel racks,” HI-2135462, Rev.2 (2014).