Method to Determine the Simplified Fuel Assembly Model for a Spent Fuel Rack Seismic Analysis From the Reactor Vessel Internal Seismic Analysis Model

Dong-Hak Kim* and Yulim Shin

Korea Hydro & Nuclear Power Co., Ltd. Central Research Institute, 70, Yuseong-daero 1312beon-gil, Yuseong-gu, Daejeon, Republic of Korea

Donghak.kim@khnp.co.kr

1. Introduction

The evaluation of the fuel assembly stored in spent fuel storage rack under a seismic condition is required by U.S. Nuclear Regulatory Commission (U.S. NRC) Standard Review Plan (SRP) 3.8.4 App. D Rev.4[1]. The effect of the end-of-life(EOL) condition on the evaluation of the fuel assembly(FA) stored in spent fuel storage rack should be also considered. To consider the evaluation of the fuel assembly for the spent fuel rack seismic analysis, the method to determine the simplified fuel assembly model should be studied.

The model of the reactor vessel internals plus core are used to evaluate the response of the fuel assemblies at the core to seismic excitation. The analysis model of fuel assembly is determined from the series of tests under the boundary condition to simulate the core support and fuel alignment plates. In this paper, the method to determine the analysis model of fuel assembly for the spent fuel rack seismic analysis from that for the models of the reactor vessel internals plus core is studied. At first, the effect of boundary condition is evaluated. The other effects are discussed on the method to determine the analysis model of fuel assembly.

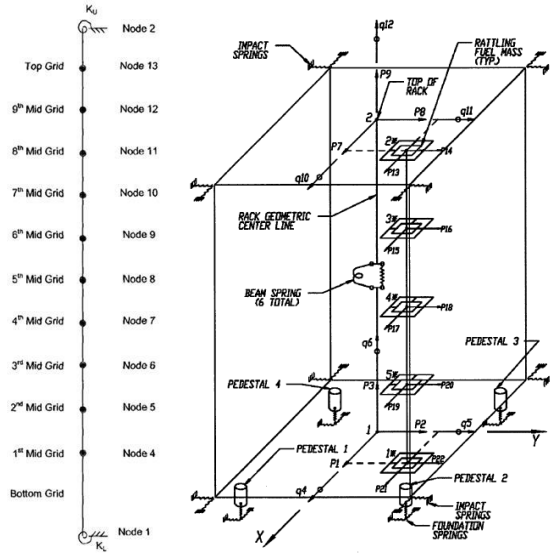
2. Simplified model of fuel assembly

Fig. 1 shows the simplified beam model of FA for reactor vessel internals[2] and the simplified beam model of fuel rack including rack and FA[3]. The beam model of FA for reactor vessel internals is determined from a series of tests under the boundary condition to simulate the core support and fuel alignment plates. Especially, the flexural rigidity of beam model is determined by simulating the test results using the beam model of FA.

The spent fuel storage rack model has the beam model for FA and rack, respectively. The beam model for FA should be determined to properly evaluate the integrity of FA and exactly simulate a motion of FA and an impact between FA and rack.

3. Effect of boundary condition

The tilt test of FA was conducted by fixing the core support and loading on the top of FA. The tilt test results are compared with the analysis results using the beam model of FA which simulates the boundary condition of tilt test. The natural frequency of an analysis model is lower than that of test results.



(a) Reactor vessel internals (b) spent fuel storage rack

Fig. 1. The simplified model of FA.

The boundary condition of tests to determine the beam model was determined to simulate the core support and fuel alignment plates. FA is compressed by fuel alignment plates. The flexural rigidity of model is determined by lowering the error of displacement between test and analysis. The displacement of center of FA is the largest value because of the fixed condition at the end of FA. The flexural rigidity of model for reactor vessel internals is determined to simulate the displacement of FA center exactly so using the beam model for reactor vessel internals to simulate FA for spent fuel storage rack should be justified.

4. Discussion

The natural frequency is the most important factor for the flexural rigidity of model. The natural frequency of FA is various with the amplitude of the vibration test. The natural frequency of FA for APR1400 reactor vessel internal is determined at the large amplitude. The natural frequency of FA for the WEC NPP such as Kori#2 was determined at the zero-amplitude. The natural frequency of FA is different between the methodologies of reactor vessel internal seismic analysis.

Also, a natural frequency of FA under end-of-life conditions is lower than that under beginning-of-life conditions. So, the effect of the FA natural frequency should be considered.

5. Conclusion

The justification for the use of a FA model for reactor vessel internal seismic analysis should be evaluated by the sensitivity analysis for the effect on the flexural rigidity of FA model. The range of the flexural rigidity should be determined by considering the effect of the boundary condition, the amplitude and EOL condition

REFERENCES

[1] U.S. Nuclear Regulatory Commission, Standard Review Plane, Section 3.8.4, Rev.4, September 2013.

[2] Combustion Engineering Report, “Structural Analysis of Fuel Assemblies for Seismic and Loss of Coolant Accident Lading,” CENPD-178-P, Rev.1-P (1981).

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