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Simplified model of isolated nuclear power plant for seismic analysis

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ABSTRACT

A seismic isolation system (or base isolation system) is one of the solution for enhance the seismic performance of the nuclear power plant. A seismic isolation system isolates the structure from the ground motion to protect the structure. If nuclear power plant is isolated by seismic isolation system, a seismic response of the structure should be re-evaluated considering randomness and uncertainty. Evaluating seismic performance of isolated nuclear power plant considering randomness and uncertainty cause a lot of effort. Using simplified model could reduce the effort. In this paper, the isolated nuclear power plant model will be simplified using simplification method. And the simplified model will be validated by comparing seismic response of fully modeled isolated nuclear power plant.

1. INTRODUCTION

A seismic isolation system is one of the solution for enhance the seismic performance of the nuclear power plant (Eem 2013). When seismic isolation system is inserted into nuclear power plant, seismic performance of the isolated nuclear power plant has to be re-evaluated. And a seismic performance evaluation of the nuclear power plant has to consider randomness and uncertainty. However considering randomness of the earthquakes and uncertainty of the model, obviously, gathering seismic information of isolated nuclear power plants from so many seismic response analyses is a monumental task (Naeim 1999). The simplification of the isolated nuclear power plant model could reduce the effort of seismic response analysis. In this paper, the simplification method is used to simplify the isolated nuclear power plant model. A simplified model is verified with comparing seismic response of fully modeled isolated nuclear power plant and the simplified model.

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2. SIMPLIFICATION MEHTOD

The isolated structure has a fundamental frequency lower than both its fixed base frequency and the dominant frequencies of ground motion, the first mode of the isolated structure involves deformation only in the isolation system: the structure above remains almost rigid (Jagnid, 1996). Assuming super-structure as rigid, Six parameters are selected which are affecting the seismic response of the isolated structure by author (Eem et al., 2013). Those six parameters are mass (M), radius of gyration (R_m), center of mass (CM), stiffness of isolation system (K), radius of disposition (R_k) and center of rigidity (CR). The simplification of isolation structure is matching those six parameters with full model, which is represented in table 1 (Eem et al. 2013). If those six parameters are matched each other, when structure subjected to earthquake
, the seismic response of the simplified model will be the same with the full model.

Table 1 Simplification of isolated structure (Eem et al. 2013)

	Full model		Simplified Model
Mass	M	=	M`
Radius of Gyration	R_m	=	R_m'
Center of Mass	CM_x, CM_y	=	CM_x', CM_y'
Stiffness	K	=	K'
Radius of Disposition	R_k	=	R_k'
Center of Rigidity	CR_x, CR_y	=	CR_x', CR_y'

3. SIMPLIFIED ISOLATED NUCLEAR POWER PLANT

In order to validate the simplification method, seismic response analysis will be performed. And seismic response of a full model and a simplified model will be compared each other. The selected structural model is Advanced Power Reactor 1400 (APR1400) for simplification. The total weight of the structural model is around 460,000 ton and the dimension is 140m x 103m. The super-structure is modeled with lumped mass and beam stick elements and the basemat is modeled with solid elements. The base isolation system is designed for the structural model with 1.5 sec target period. The isolation layer is added to the structural model, as shown in Figure 1.

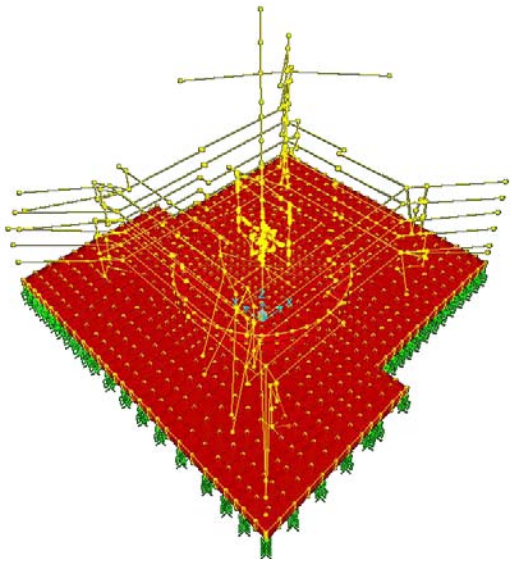
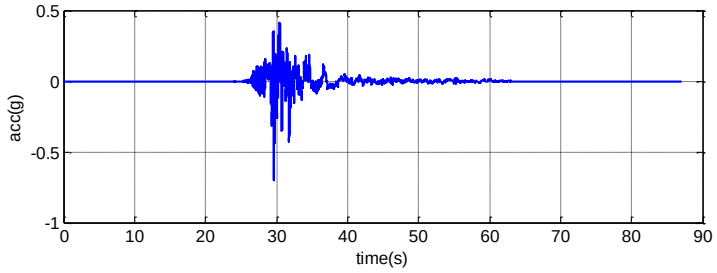


Fig. 1 Isolated nuclear power plant

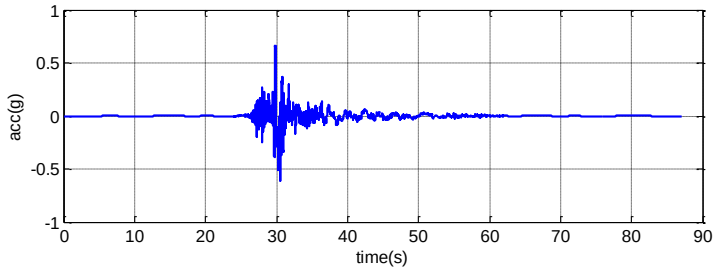
Using simplification method for the isolated structure, the simplified model is consists with 1 mass and 4 isolators.

3.1 Seismic response analysis

The same earthquake input is used for both models to compare seismic response results. Using RSPmatch program, the Imperial Valley earthquake is revised to match with target spectrum which is in NRC Regulatory Guide (RG) 1.60.



(a) x-direction



(b) y-direction

Fig. 2 Input earthquakes

Figure 3 compares the time histories of the x and y displacement. The results show that the simplified model's results correspond quit well with full model's behavior.

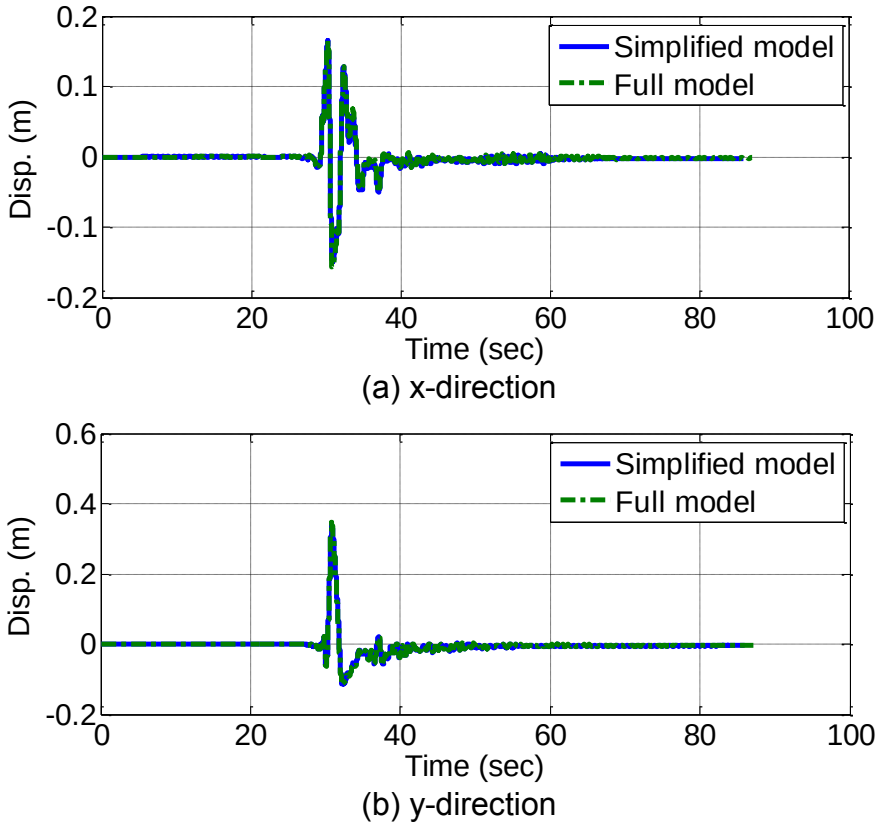


Fig. 3 Response of isolated structure model

4. CONCLUSIONS

In this paper, the isolated nuclear power plant model, which is APR1400, is simplified using the simplification method. The simplification method is matching six parameters which are affecting the behavior of the isolated structure. Matching those parameters, the simplified isolated model is generated from the isolated nuclear power plant, which is APR1400. And it is verified by comparing results of seismic response analysis with full model of isolated nuclear power plant. The simplified isolated nuclear power plant model gives accurate earthquake response.

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