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Structural Integrity Analysis of Pool Cover

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1. Introduction

A pool cover is designed to protect the reactor and provide working space on the pool top area. It is composed of PC-A, PC-B, SP, and ERs. There are two cases according to the position of the SP. Fig. 1 shows the close mode and Fig. 2 shows the open mode.

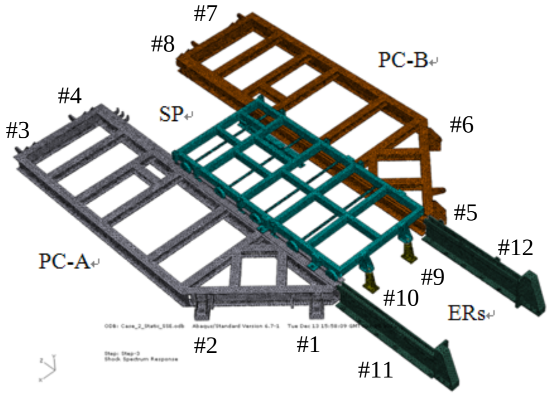

Fig. 1. Closed pool cover

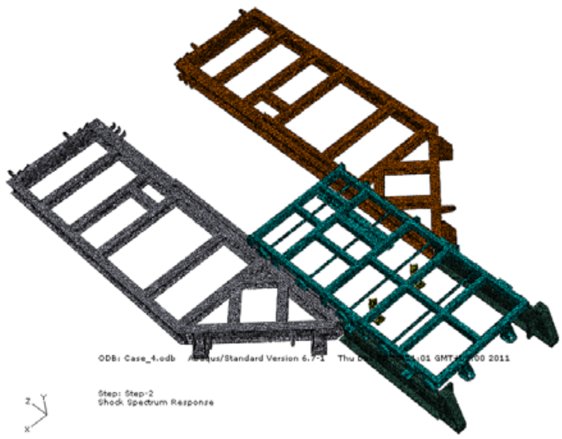

Fig. 1. Open pool cover

In this study, the structural integrity of the pool cover for the postulated service loading is evaluated. A floor Response spectrum analysis is employed as a seismic analysis method.

2. Code Application

2.1 Allowable Stress

The structural integrity of the pool cover, classified seismic category II, has been evaluated according to ASME III NF code.

2.2 Load Combinations

The service level A loadings include dead loads and live loads, i.e., the weight of the main beam, movable hook, NTD driving device, grating with polycarbonate, and 0.5 ton/m^2.

A SSE seismic load for service level D loadings is assumed to occur in combination with service level A loadings. For a structural dynamic analysis, a mass equivalent to the 25% of a live load is added to the structural mass.

3. Modeling and Analysis

3.1 Modeling

The finite element model of the pool cover is performed using ABAQUS software. The elements used in the analysis model are a solid element and nonstructural mass element. The total number of elements is 312,174, and the total number of nodes is 100,508. The sub-structures and live loads are modeled using a non-structural mass. The total weight of the pool cover including the live load is about 9,520kg.

3.2 Boundary Conditions

The translational 3 degrees of freedom of the nodes near the anchor bolt holes are constrained. Fig. 1 shows the locations of anchor bolts (#1~#12).

3.3 Static Analysis

A static analysis is performed to confirm the stress levels for the structural components of the pool cover when the pool cover is subjected to dead and live loads.

3.4 Seismic Analysis

To investigate the dynamic characteristics of the pool cover, a modal analysis is performed using the finite element model. The typical measure of the dynamic characteristics, natural frequencies, and mode shapes are obtained. Figs. 3 and 4 show the mode shapes of model. It can be observed that the first natural frequencies are 20.9 and 26.9 Hz, respectively. A response spectrum analysis has been performed to evaluate the structural responses of the pool cover under a seismic event. The square root of the sum of the squares (SRSS) method is used to combine the total response in each direction. The FRS curves with the suitable damping value shall be applied according to the boundary condition of the components. An FRS with 7% damping is applied to the response spectrum analysis since the boundary condition of the structure is similar to the bolted steel with a bearing connection.

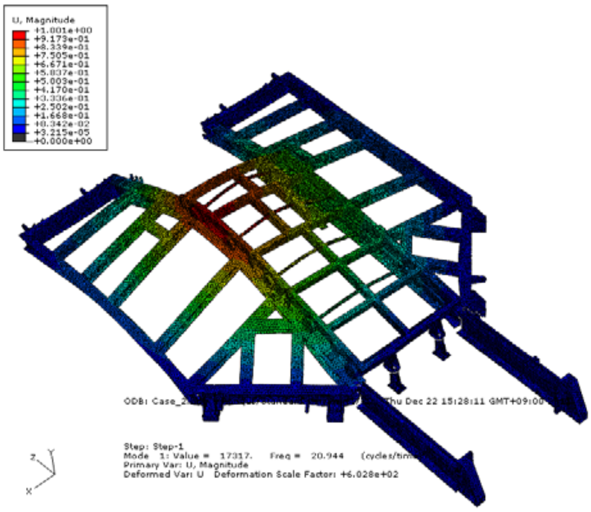

Fig. 3. First mode 20.9Hz in closed case

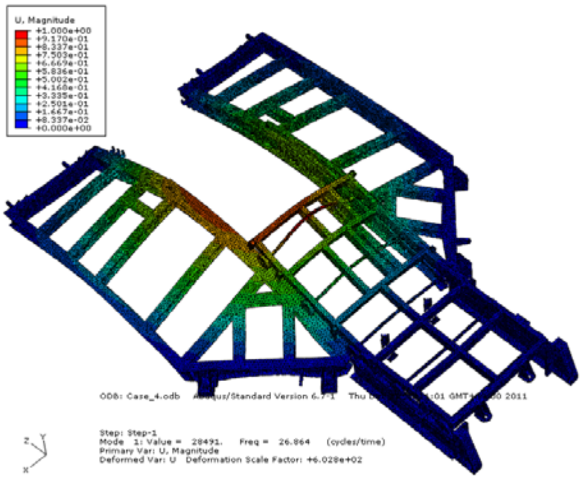

Fig. 4. First mode 26.9Hz in open case

3.5 Results

Two cases of the analysis have been performed. When the static and seismic loadings are applied, the maximum Tresca stress of the pool cover occurred at the mid position of main beam.

The maximum displacement of the pool cover in the closed case is about 3.1mm at the sliding panel wheel shaft and that of the PC-A main beam and SP main beam during service level D are about 2.3mm and 2.8mm, respectively. The maximum displacement of the pool cover in the open case is about 2.2mm at the sliding panel wheel shaft, and those of the PC-A main beam and SP main beam during service level D are about 1.7mm and 1.8mm, respectively.

4. Conclusion

These analysis results show that stresses for the pool cover under service loading conditions are within the ASME III NF code limits.

REFERENCES

[1] ASME B&PV Section III Div. 1 Sub-section NF, 2007.
[2] ABAQUS v6.4 User Manuals, ABAQUS Inc., 2003.
[3] Regulatory Guide 1.61, Damping Values for Seismic Design of Nuclear Power Plants, U.S. Nuclear Regulatory Commission, 2007.