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Structural Integrity of Pool Bridge for Research Reactor

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1. Introduction

The pool bridge is a moving deck system on the reactor pool. The conceptual configuration of the pool bridge is shown in Fig. 1. Operators can access the top of the pool while on the pool bridge. The pool bridge travels along the rails from the end of the pool to another end. The structural integrity of the pool bridge must be maintained during an earthquake. The strength of the structural members is evaluated through the finite element analyses.

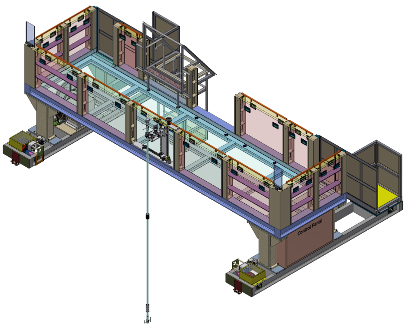


Fig. 1. Configuration of the pool bridge

2. Methods and Results

2.1 Model

The finite element model of the pool bridge is generated as shown in Fig. 2 by using ANSYS software. Shell elements are used for the structural members. The total number of nodes and elements are 41,261 and 34,013, respectively. The non-structural components are considered as distributed mass. Total mass is about 8 tons. Boundary conditions are consistent with those specified in KEPIC MCN[1] or ASME NOG-1[2]. Translations of 4 wheel axles are constrained in different directions.

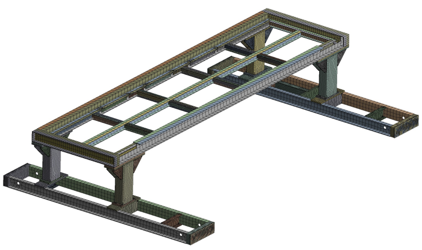


Fig. 2. Finite element model

2.2 Static Analysis

The total weight of the pool bridge is considered as dead load in the static analysis. The horizontal load transverse to the bridge is also induced by the acceleration or deceleration along runway rail. The transverse horizontal load is taken as 5% of the dead load.

The maximum von Mises stress is 55 MPa, which is less than half of yield stress of A240 304L type stainless steel[3]. The stress distribution is shown in Fig. 3. The maximum reaction force at the wheel axle is 30 kN. The equivalent stress is approximately 13 MPa in the steel shaft with diameter of 55 mm.

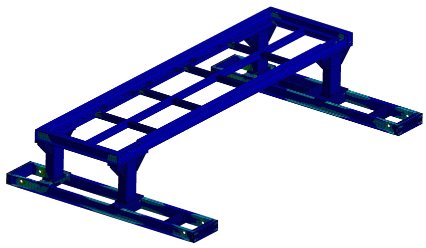
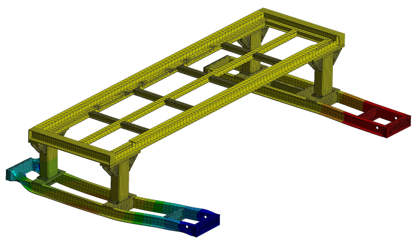


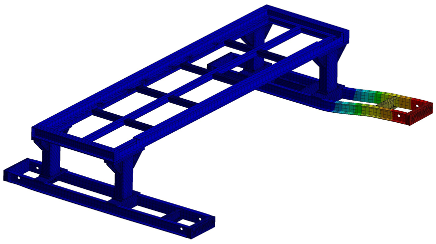
Fig. 3. Distribution of von Mises stress

2.3 Modal Analysis

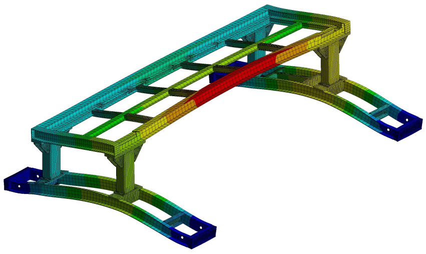
The dynamic characteristics of the pool bridge are investigated through a modal analysis. Mode shapes in the first 3 modes are shown in Fig. 4. Natural frequencies for the first 3 modes are 8.8, 19.8, and 22.8 Hz.



(a) 1st mode



(b) 2nd mode



(c) 3rd mode

Fig. 4. Mode shapes: (a) first mode, (b) second mode and (c) third mode.

2.4 Response Spectrum Analysis

The structural responses to the safe shutdown earthquake are evaluated through a response spectrum analysis. Total 100 modes are considered in the modal response combination. The total response in each direction is evaluated by using the square root of the sum of the squares.

Under the extreme environmental condition, dead loads and seismic loads are combined for the analysis. The maximum von Mises stress is 55 MPa. The allowable stress is 153 MPa, which is 90% of yield stress. The evaluated stresses under the extreme environment condition satisfies the criteria of KEPIC MCN and ASME NOG-1.

3. Conclusions

The structural integrity of the pool bridge is evaluated during the design process. Boundary conditions and loads combinations of KEPIC MCN are used in the stress evaluation. Response spectrum method is used to evaluate responses to earthquake. The design of the pool bridge satisfies structural requirements in the codes and standards.

Acknowledgements

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REFERENCES

[1] Korea Electric Power Industry Code, MCN, Cranes for Nuclear Facilities, Korea Electric Association, 2005.
[2] ASME NOG-1, Rules for Construction of Overhead and Gantry Cranes, American Society of Mechanical Engineers, 2002.
[3] Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications, ASTM International.