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Structural Analysis of Cabinet Support under Static and Seismic Loads

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1. Introduction

The cabinet support is a structure that supports the cabinet for electrical equipment such as a neutron measurement system (NMS) and reactor gamma monitoring system (RGMS). The electrical cabinet is mounted on the cabinet support. The cabinet support consists of frames including steel channels and steel square tubes. Four tap holes for screw bolts are located on the support frame of a steel channel to fix the cabinet on the support. The channels and square tubes are assembled by welded joints. The cabinet supports are installed on the outer walls of the reactor concrete island. The KEPIC code, MNF [1], is used for the design of the cabinet support.

In this work, the structural integrity of the cabinet support is analyzed under consideration of static and seismic loads.

2. Methods and Results

2.1 FEM Model

A finite element model is used in the structural analysis of the cabinet support using ANSYS v.15 software. The finite element model for the analysis is shown in Fig. 1. The finite element analysis uses varying types of elements such as shell elements (SHELL281) and nonstructural mass elements. The total numbers of elements and nodes are 9,995 and 30,825, respectively. The frames of the steel channel and square tube are modeled using shell elements. The mass of the RGMS cabinet and its contents is about 100 kg. The mass of the cabinet support is 59 kg. Boundary conditions shall be consistent with the rational displacements, deformations, and reaction forces in the structure.

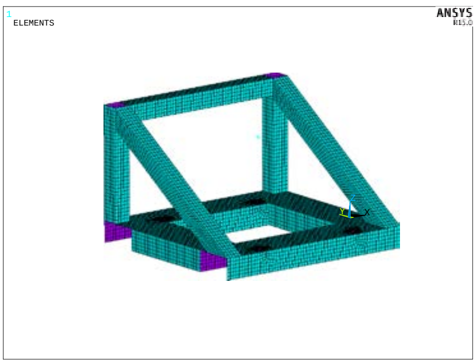

Fig. 1. Finite element model of the cabinet support.

2.2 Static Analysis

A static analysis is performed to check the stress levels for the structural components of the cabinet support under service level A, which considers the dead load only. The dead load is the weight of the cabinet support and the cabinet including its contents.

The maximum membrane stress is 17.0 MPa and the maximum values of the membrane plus bending stress is 23.0 MPa. The distributions of stresses in the structure are shown in Fig. 2. The maximum stress is observed on the steel square tube near the joint connecting to the steel channel.

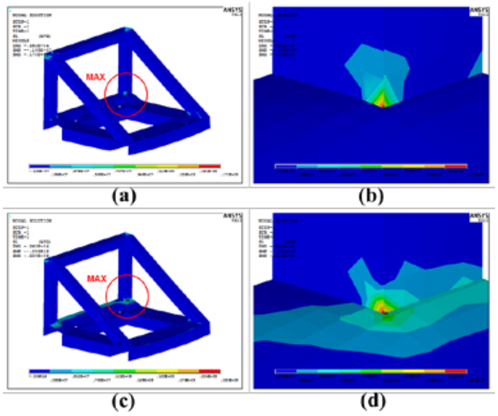

Fig. 2. Stress distribution under service level A Loading: Membrane stress (a) in full view and (b) in local view; and membrane plus bending stress (c) in full view and (d) in local view.

2.3 Modal Analysis

A modal analysis is carried out to investigate the dynamic characteristics of the cabinet support. Natural frequencies, mode shapes, and typical measures for the dynamic characteristics of structure are obtained in the analysis. Natural frequencies and mode shapes are shown in Fig. 3. The natural frequency for the first mode is 93.3 Hz.

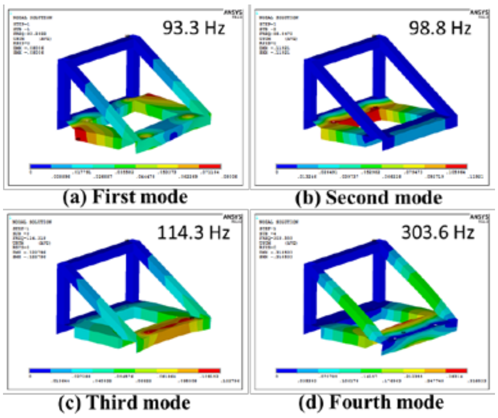

Fig. 3. Mode shapes and natural frequencies of the cabinet support: (a) First mode, (b) second mode, (c) third mode and (d) fourth mode.

2.4 Seismic Analysis

A response spectrum analysis is conducted to evaluate the structural responses of the cabinet support during the seismic event. A total of 200 modes are considered in the modal response combination so that the modal effective mass reaches 90% of the total mass. The square root of the sum of the squares (SRSS) method is used to combine the total response in each direction. The floor response spectrum (FRS) curves with the suitable damping value are used under consideration of the connection types and boundary conditions of the structure.

Under a level B service loading, which considers dead loads and operating basis earthquake (OBE) seismic loads, the maximum membrane stress is 19.9 MPa and the maximum values of membrane plus bending stress is 30.0 MPa. The distributions of stresses in the structure are shown in Fig. 4.

Stress intensities are evaluated for the level D service loading, which considers dead loads and safe shutdown earthquake (SSE) seismic loads. The maximum primary membrane stress intensity is 28.5 MPa and the maximum value of primary membrane plus primary bending stress intensity is 37.1 MPa. As shown in Fig. 5, the distributions of stresses in the structure are similar to those for level A and B service loadings.

The stresses in the cabinet support are much lower than the yield stress of structural steel (248 MPa). The strength of the cabinet support is sufficient to withstand the seismic loads.

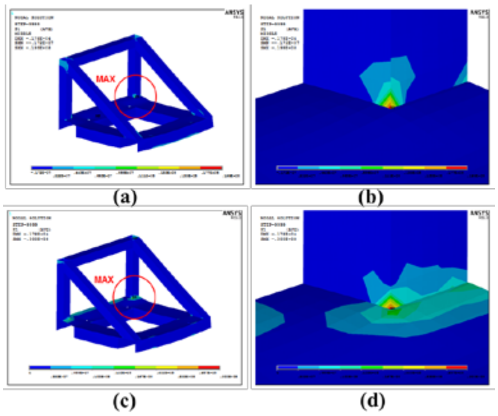

Fig. 4. Stress distribution under service level B Loading: Membrane stress (a) in full view and (b) in local view; and membrane plus bending stress (c) in full view and (d) in local view.

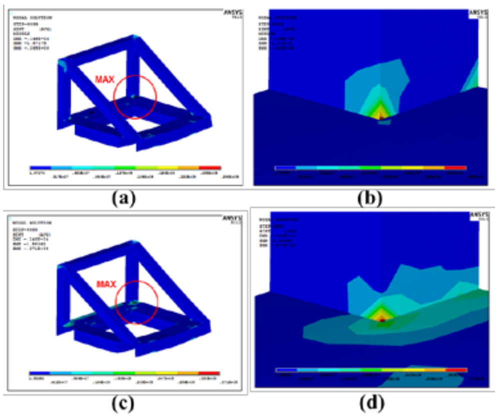

Fig. 5. Stress distribution under service level D Loading: Primary membrane stress intensity (a) in full view and (b) in local view; and primary membrane plus primary bending stress intensity (c) in full view and (d) in local view.

3. Conclusions

A 3-D finite element model of the cabinet support was developed. The structural integrity of the cabinet support under postulated service loading conditions was evaluated through a static analysis, modal analysis, and response spectrum analysis. From the structural analysis results, it was concluded that the structural integrity of the cabinet support is guaranteed.

Acknowledgements

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REFERENCES

[1] KEPIC Code MNF, Korea Electric Association, 2005.