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Seismic Analysis of Electrical Panel

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***Abstract:** Equipments used at nuclear power plants require robust and reliable designs because in case of disaster, such as earthquake, small damage can turn into an unpredictable result. The analysis has been done using Finite Element Method (FEM), a common tool used for the analysis of structures. To conduct seismic analysis, it is necessary to perform modal analysis and calculate response spectrum from the Floor Response Spectrum.*

In the present project, data is obtained from the modal analysis using ANSYS software for panel assembly structure model. The Floor Response Spectrum (FRS) data for the geographical region where this structure will be mounted is collected. The collected data is given as input to response spectrum analysis where it subjected to these conditions. The output of this analysis determines whether the structure that has been designed is within the safety limit or not.

In the present project a 3d model of the Electronic panel assembly structure is modeled using UNIGRAPHICS modeling software. The model is converted to parasolid and imported into Ansys. As a first step modal analysis has been performed to predict the fundamental frequency of the structure. Later dynamic analysis has been performed to evaluate the seismic response of the system under Operation Basis Earthquake (OBE). The response spectra used for OBE in X, Y, Z directions are given as input. The dynamic analysis has been performed to determine the stresses developed in the beam and results obtained have been compared to ASME standards. Based on the results obtained design optimization of the structure has been carried out.

***Keywords:** Siesmic analysis, Floor Response spectrum, Unigraphics, Operation basis earthquake.*

I. INTRODUCTION

Earthquake engineering has developed a lot since the early days, and some of the more complex designs now use special earthquake protective elements either just in the foundation (base isolation) or distributed throughout the structure [1]. Analyzing these types of structures requires specialized explicit finite element computer code, which divides time into very small slices and models the actual physics, much like common video games often have "physics engines". Currently, Wyle, Ellis & Watts [2] of the United States perform most of the seismic analysis and design in Korea. Authors conducted experiments in order to improve seismic technology in Korea. Seismic technology can be roughly categorized into analysis and experiments. The best way is testing the final product but this process involves making actual prototype, which is time consuming and also expensive [3]. The general method followed in most of the industries is performing analysis by simulation using finite element method where it is subjected to similar conditions to that of experiments as this not only saves time but also it is found to be more efficient and effective than the conventional methods [4-5].

Large-capacity ground-supported panels are used to store a variety of electronic equipment. Satisfactory performance of panels during strong earth quake is crucial for modern facilities. The panels that were designed earlier were without the consideration of earth quake and they have suffered extensive damage when earthquakes have occurred [5]. As it is well known fact all structures gets damaged during earthquake and it is found that damage to steel storage panels can take several forms. Large axial compressive stresses due to beamlike bending of the panel wall can cause "elephant-foot" buckling of the wall. High stresses in the vicinity of poorly detailed base anchors can rupture the panel wall. Base shear can overcome friction causing the panel to slide [7].

II. PROBLEM DESCRIPTION

Natural disasters are inevitable and it is not possible to get full control over them. The history of human civilization reveals that man has been combating with natural disasters from its origin but natural disasters like floods, cyclones, earthquakes have various times not only disturbed the normal life pattern but also caused huge loss to life and property and interrupted the process of development.

With the technological advancement man has tried to minimize the effect of these natural disasters through various ways like developing early warning systems for disasters, proper relief and rescue measures. Earthquakes are one of such disasters that are related with ongoing tectonic process it occurs suddenly for seconds and causes huge loss to life, property and ecosystem.

In order to contain these effects man has developed systems that can predict the seismic activity at any location on the earth. With use of this equipment it is found that every site has a specific seismic response at which ground shaking can be amplified and if it matches with the fundamental frequency of the manmade structure it can be inferred that probability of damage is maximum [].

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III. MODELING OF ELECTRICAL PANEL

As part of approach to the solution the first step is modeling of the panel with specified dimensions using UNIGRAPHICS, 3-D modeling software.
The views of various 3D model of the panel after completion of modeling is shown in Fig. 1.

3D models of the panel done in UNIGRAPHICS

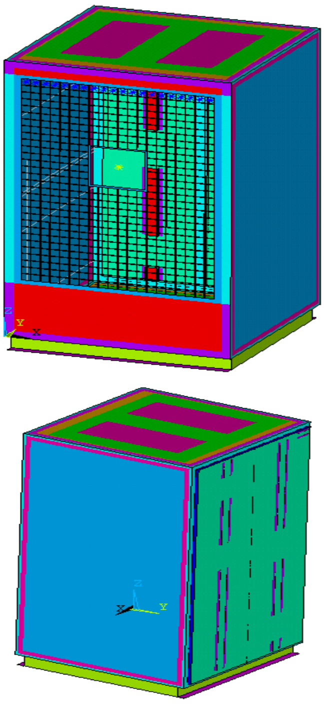

Fig. 1 3D Model of Panel

IV. SEISMIC ANALYSIS OF THE ELECTRICAL PANEL

The following analysis was carried out to study the structural integrity of the "Electrical Panel" under various loading conditions:
Modal analysis to study the fundamental frequencies of the monitor.
Seismic analysis with OBE (Operation Basis Earthquake) loads.
Calculation of stresses in the beam elements as per ASME for the following load cases:
Load case-1: dead weight + OBE.

A. **Steps Involved In Analysis**

The 3D model is converted into parasolid and imported into ANSYS which works on Finite element method where discretization of the model is done to carry out the Modal and Seismic analysis.

2. As part of preprocessing the boundary conditions and loading is then applied to
this model. Then the problem is run to get the solution.
3. Once the solution is obtained the Post Processing of the results is done using Post processor.

B. **Material Properties (As Per Data Sheets) For Steel**

Young's Modulus = 2e11 N/m^2
Poisson's Ratio =0.3
Density = 7850kg/m^3
Yield Strength = 260 e6 N/m
The Panel was studied to understand the natural frequencies between 0-33Hz.

C. **Boundary Conditions/Loads:**

Operating frequency range of the unit: 0 - 33 Hz
Boundary conditions:
Weight of the structure = 533 Kgs.

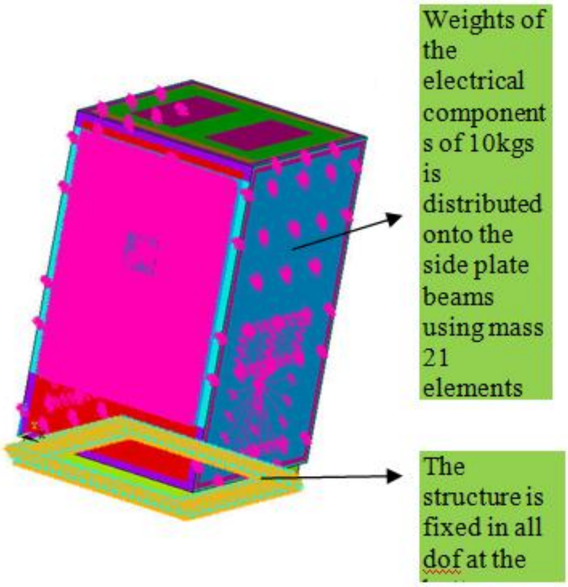

Fig. 2 Weights applied on the panel

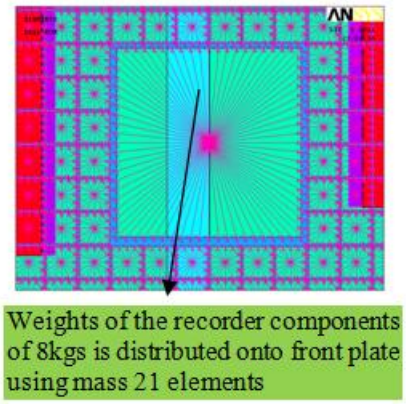

Fig. 3 Weights on Front plate

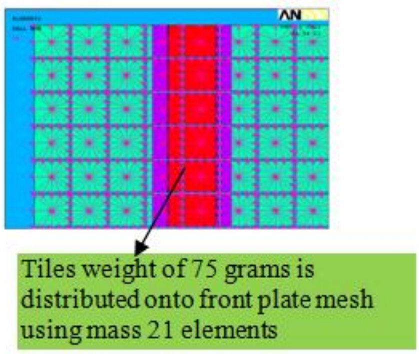

Fig 4. Weights on Front plate

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From the above results it is observed that the first mode is less than 33Hz; therefore it is necessary to conduct seismic analysis. Also the participation factors are different on each direction because of the structural characteristic. Generally, the earthquake waves are given as random function in time domain. To obtain structural response, Response Spectrum Analysis (RSA) method is widely used because combining frequency spectrum of earthquake wave and modal frequency yields RRS. If the first mode frequency exists less than 33Hz, resonance is likely to occur. Therefore it is necessary to calculate the natural frequency from modal analysis and find acceleration value for each mode from response spectrum. Then it is possible to obtain combined stress from earthquake waves on all 3 directions by running RSA by results from ANSYS and then using SRSS method from equation.

From the above modal analysis results it is also found that there are 10 natural frequencies between 0-33Hz. From the participation factors of each mode shown above it is found that frequencies 15.85Hz, 15.90Hz, 20.26Hz have huge mass participation of above 5% of the total weight of the structure.

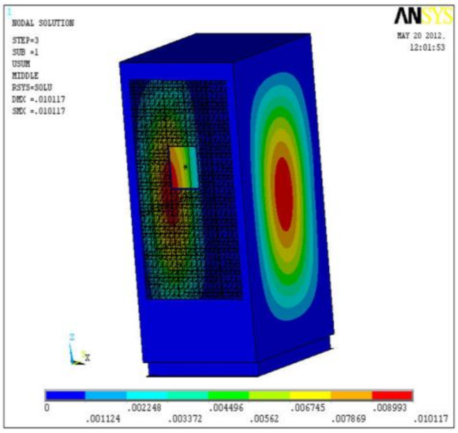

Fig. 5 Displacement Magnitude

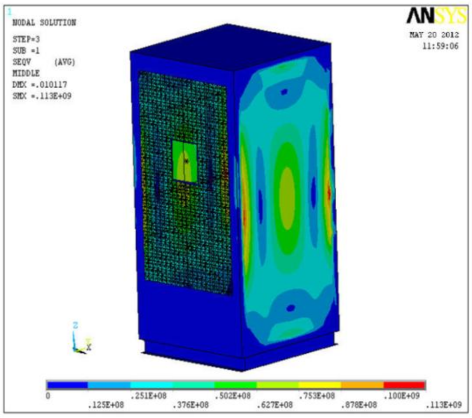

Fig. 6 Von mises Stress distribution

Max displacement– side plates - 10mm.
Von-mises stress on side plates – 113e^{6} N/m^{2}

V. SEISMIC ANALYSIS OF THE MODIFIED PANEL

From the above modal results it is observed that the critical frequencies are 15.85Hz, 15.90Hz, and 20.66Hz where resonance may occur and response excitation is high which may cause damage to the panel structure.

From the above modal analysis results and from the mode shapes at frequencies 15.85Hz, 15.90Hz, 20.66Hz it is also observed that it is necessity to strengthen the side cover plates where maximum displacement is observed, so as to avoid failure at these critical frequencies.

The strengthening to the side cover plates has been done by welding the plates to the C-section beam as shown.

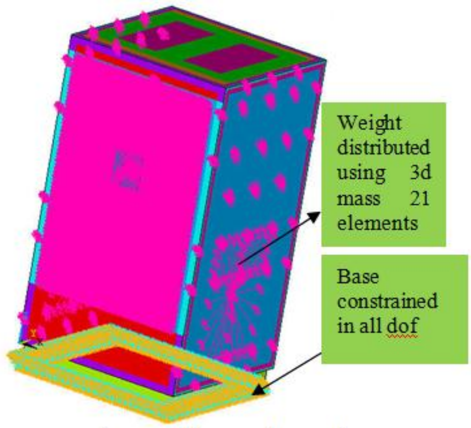

Fig. 7 Boundary conditions on the panel

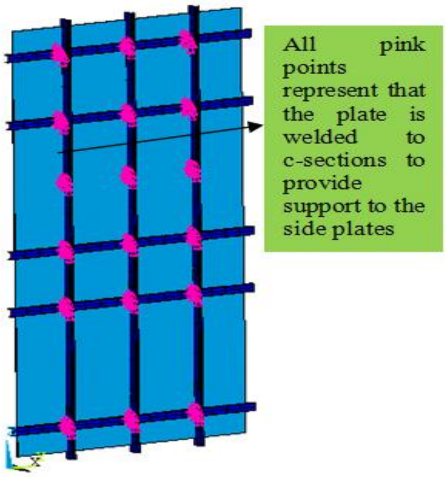

Fig. 8 Boundary conditions on the side plate

The modal analysis is carried out on the modified model and the results are shown below. Only 3 natural frequencies were found between the frequency ranges of 0-33Hz.And failure at the critical frequencies 15.85Hz, 15.90Hz, and 20.66Hz has been eliminated by welding the side plates to the C cross section beams.

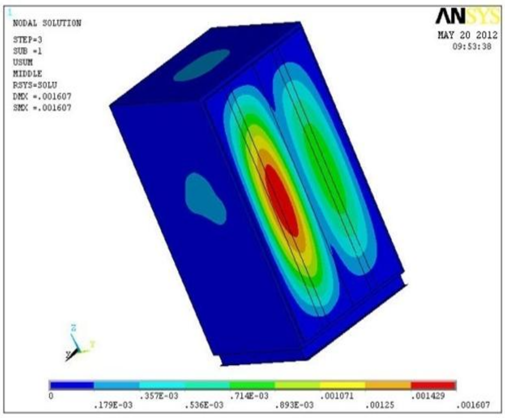

Fig.9 Displacement Magnitude

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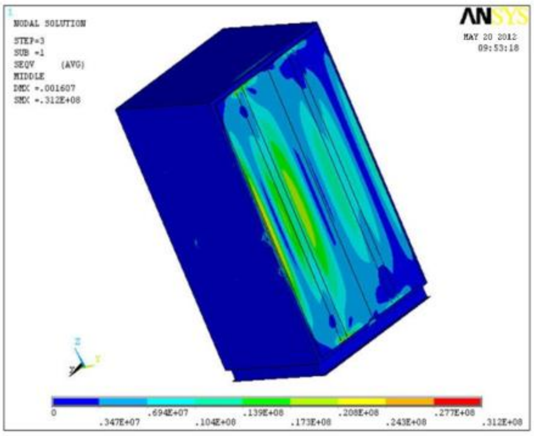

Fig.10 Von mises Stress distribution

VI. RESULTS AND DISCUSSIONS

Table 1. Major participations in three directions

***** PARTICIPATION FACTOR CALCULATION ***** X DIRECTION				
Mode	frequency	partic.factor	ratio	effective mass
1	21.22	0.32	0.16	0.10
2	26.15	1.98	1.00	3.92
3	27.11	0.53	0.27	0.28
******* PARTICIPATION FACTOR CALCULATION ***** Y DIRECTION**				
MODE	**FREQUENCY**	**PARTIC.FACTOR**	**RATIO**	**EFFECTIVE MASS**
1	21.22	5.59	1.00	31.00
2	26.15	-2.13	0.38	4.14
3	27.11	-0.86	0.15	0.74
******* PARTICIPATION FACTOR CALCULATION ***** Z DIRECTION**				
MODE	**FREQUENCY**	**PARTIC.FACTOR**	**RATIO**	**EFFECTIVE MASS**
1	21.22	-0.76	0.15	0.58
2	26.15	0.53	0.11	0.28
3	27.11	-4.76	1.00	22.70

Table 2. Maximum Displacement and VonMises stresses in the structure along three directions

Direction	USUM(mm)	Location	VonMises x (E6 N/m2)
X	1.60	Doors	31.2
Y	1.70	Doors	20.9
Z	7.60	Doors	25

As per ASME Section III subsection-NF 3320 the yield strength (Sy) of the Material (steel) is 260 x 10^6 N/m^2.

From the above analysis results the Von-Mises Stress and Bending stress are less than the allowable stress and allowable bending stress respectively.

Table 3. Response of the structure for the applied PSD along three directions

Direction	Frequency (Hz)	Acceleration (m/s2)	Location
X	26	22.5	Side Plates
Y	21	79	Doors
Z	27	57	Top Plates

The results of modified model are within the limits as per ASME Section III subsection-NF 3320 and response excitation is also less when compared to the original model.

VII. CONCLUSIONS

In this project, the electrical panel was modeled and undergone analysis in ANSYS.

The modal analysis has been carried out on the electrical panel. It is found that there are 10 natural frequencies between 0-33Hz. From the participation factors of each mode it is found that 15.85Hz, 15.90Hz, and 20.66Hz have huge mass participation of above 5% of the total weight of the structure.

It is observed from seismic analysis that there are huge excitations at the frequencies 15.85Hz, 15.90Hz, and 20.66Hz. These excitations are very damaging to the structural panel and there is a need to eliminate failures these critical frequencies.

The modal analysis has been carried out on the modified model. Of various frequency ranges that are available, 3 natural frequencies were found to be effective and they lie between the frequency ranges of 0-33Hz. Further it is found that at critical frequencies 15.85Hz, 15.90Hz, and 20.66Hz failure has been eliminated by welding the side plates to the beams having C cross-section.

It is predicted from seismic analysis that Von Mises Stresses are 31.2 x 10^6 N/m^2 in X direction, 20.9 x 10^6 N/m^2 in Y direction, 25 x 10^6 N/m^2 in Z direction which are very much less than the allowable stress of 260 x 10^6 N/m^2 as per ASME standards.

It can be concluded from the results obtained for the of modified panel lies within the limits as per ASME standards and response excitation is also less when compared to the original model. Therefore the modified panel is safe under the OBE loading.

REFERENCES

1. J. Lee, J. Kim, P, Jung, J, Jung, “Seismic analysis of axial blower for nuclear power plant use”, *Journal of Korean Society for Noise and Vibration Engineering*, 1999, 9, 535 – 543.
2. William T. Thomson, Marie Dillon Dahleh, *Theory of Vibration with Application*, 5th Ed., Prentice Hall, 1993.
3. Gupta, Ajaya K., “Response Spectrum Method in Seismic Analysis and Design of Structures”, *CRC Press*, 1992.
4. EERI Monograph on "Earthquake Design and Spectra", *new mark and Hall*, 1982.
5. Leonard Meirovitch, “Analytical Methods in Vibrations”, *Macmillan Publishing Co.*, 1970, New York.
6. M Vishnu Vardhan, G Sankaraiah, M Yohan, “Effect of cryogenic treatment of tungsten carbide tools on cutting force and power consumption in CNC milling process”, *Production and manufacturing Research,2018, 6(1),149-170.*
7. M Vishnu Vardhan, G Sankaraiah, M Yohan,“Optimization of Parameters in CNC milling of P20 steel using Response Surface methodology and Taguchi Method”, Materials today Proceedings, 2017, 4(8), 9163-9169.

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