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DETERMINATION OF EARTHQUAKE DESIGN RATIO FOR FIXED OFFSHORE PLATFORM DUE TO ACEH EARTHQUAKE IN MALAYSIA

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A R T I C L E I N F O

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A B S T R A C T

The level of concern among civil engineers in Malaysia about the aspect to design the structural for earthquake design criteria is low. But there are some cities or countries occur earthquake very often such as Aceh, Indonesia. Actually the tremors happened in Malaysia region due to Aceh earthquake and it also affected fixed offshore structure in Malaysia which not all of the offshore structure in Malaysia designed to resist seismic loading. The objective of this study is to determine the earthquake design ratio for fixed offshore platform due to Aceh earthquake in Malaysia. All the environmental factors data are given such as ranges of wave height and ground motion acceleration. The environmental loadings such as wave and wind load have been designed by referring API (American Petroleum Institute) design criteria. There were three types of analysis had been carried out which were Free vibration analysis, Response spectrum analysis and Time history analysis. For the Response spectrum analysis, the analysis performed by using response spectra curves of EuroCode8. Time history analysis has been performed by referring to time history of earthquake in Aceh 2004. The computer software SAP2000 was selected to analyse this structure and the design code for the steel frame is EuroCode3. As a result, the offshore platform were very stable when hit by the earthquake. It can be conclude that different design ratio gain from the analysis and most of the part of the structure were in good performance and condition.

1. Introduction

In Malaysia, there are several areas that have existing offshore platform structure operate 24 hours all the day. The seismic waves is created by earthquake when the Earth's crust sudden release of energy. The earthquakes are measured by using seismometers. If the Magnitude is less than or equal to 3, that will consider almost imperceptible or weak. If the Magnitude is 3 to 7, that will causing massive damage to the larger areas, it is depending on their depth.

The largest earthquakes happened in historic times is the magnitude 9 over, there is no limit for a significant values of magnitude. When the building structure experiences earthquake, it will caused structural damage. And it can be expected because all building codes are only allow the inelastic energy. Which the normal buildings only can resist inelastic energy and the loading caused by dead load and live load will dissipate in structural systems. (Tze Khai, 2007).

By using the modern seismic code (EC8) to minimize the damage caused by earthquake in future. There are two earthquake regions in Asia area, Indonesia and Philippine. But the distance of

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earthquake zone that most near to Malaysia is Indonesia, Aceh. From the record of United States Geological Survey (USGS), earthquake was happened every year in Aceh, maybe in month or within few weeks. The largest shock occurred in the past was in 26 December 2004, the magnitude is up to 9.1, it's caused by undersea megathrust earthquake. From the USGS database record, this largest earthquake in Asia was affected many states and cities in Malaysia. The information of Aceh earthquake in 2004 are shown in Figure 1.

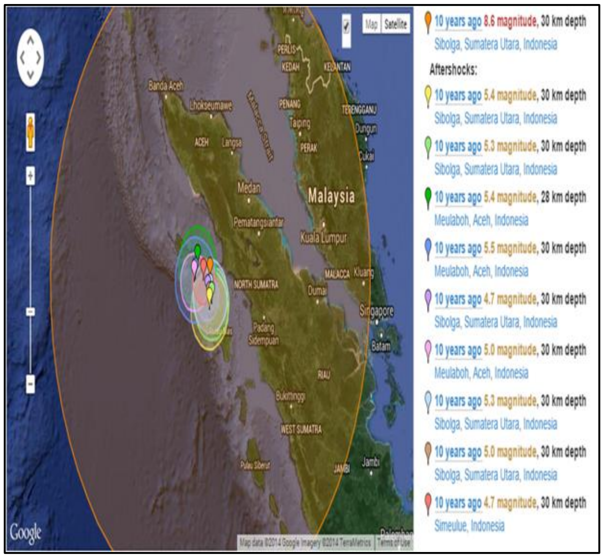

Figure 1: 9.1 Magnitude Aceh Earthquake in 2004

The large magnitude of earthquake trigger the big tsunami and the environmental forces, such as wind and wave load. Many cities were affected because that earthquake including cities in Malaysia such as Johor Bahru, Pulau Pinang and Kedah.

2. Methodology

In this study, the fixed offshore platform (four-legged) have been identified for the modelling and analyses. After modelling process have been done by using the analysis software, which is SAP 2000, the response spectrum, time history and free vibration analyses will be performed. For the load combinations, it involved self-weight of the structure, dead load of the structure (deck load), environmental loads and earthquake load.

The environmental loads such as current load; wave load and wind load for the fixed offshore platform structure will be determined by set the location of the structure at specific location in the Malaysia region and determine all the loads by using API design criteria standard.

For the response spectrum analysis, it will be analysed by using the curve of response spectra in EC8. For the time history analysis, it will be analysed by using the time history earthquake values which obtained from Meteorological Malaysia Department (MMD). For the free vibration analysis will provide the natural period and the mode shape of the structure. All the responses from the fixed offshore platform structure due to earthquake will be determined. The software used to perform these three analyses were also SAP2000.

3. Results and Discussions

The assessment of earthquake load to the structure would be cover by the static and earthquake analyses by using the API RP 2A-WSD criteria. SAP2000 has been used while code checks were performed according Eurocode3-2005. The input of time history was gotten from Malaysia Meteorological Department and processed using SAP2000 software as shown in Figure 2.

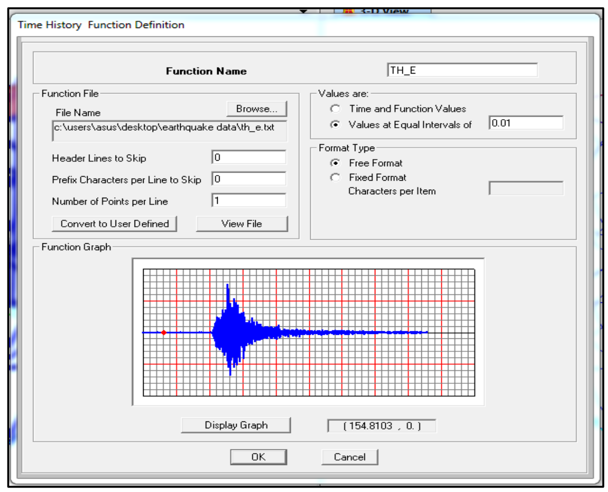

Figure 2: Time History Graph in SAP2000 Computer Software

According to Wan Ahmad et al. (2015) and Mohd Noor et al. (2016), different analysis and equation were used for strike slip and subduction mechanism. For this study, source of the earthquake was classified in strike slip area. The maximum acceleration for time history is 0.0018m/s^2. For the response spectrum, the analysis was done using the curve suggest by Eurocode-8 and shown in Figure 3.

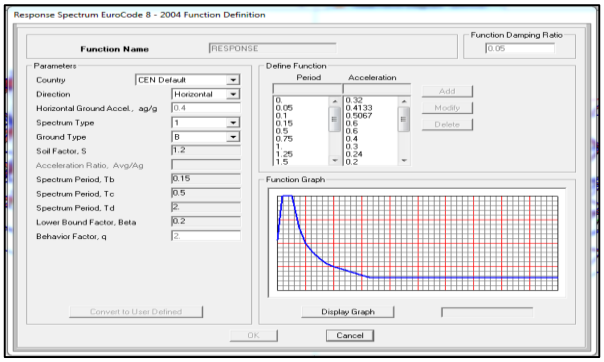

Figure 3: Response Spectrum Graph in SAP2000 Computer Software

Taib et al. (2014) was identified that vertical earthquake have to take into consideration in the analysis and design for certain case. For this study, horizontal earthquake govern the value of excitation from vertical part. The maximum acceleration for this earthquake is 0.6 m/s2 at 0.1883sec to 0.5005 sec.

3.1 Free Vibration Analysis

For free vibration analysis, there are numbers of mode shape that can be generated. Some of the mode shape selected to view possible movement of the structure as shown in Figure 4 and Figure 5. Figure 6 shows twelve mode shape result that was generated from SAP2000 software.

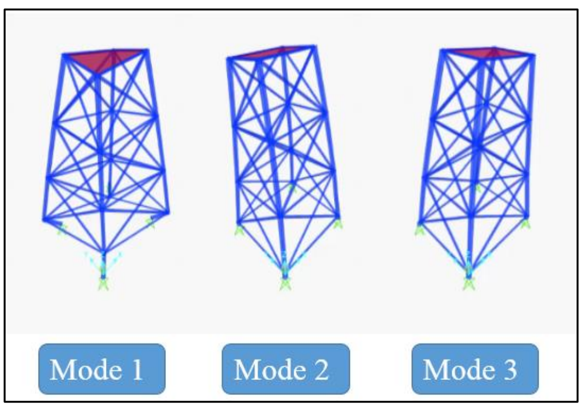

Figure 4: The First to Third Mode Shape of the Structure

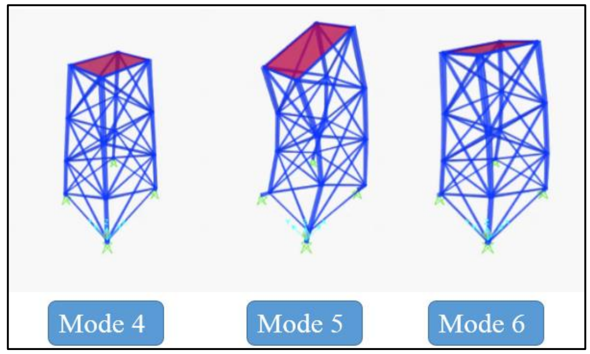

Figure 5: The Fourth to Sixth Mode Shape of the Structure

Modal Periods And Frequencies

File View Format-Filter-Sort Select Options

Units: As Noted — Modal Periods And Frequencies

OutputCase Text	StepType Text	StepNum Unitless	Period Sec	Frequency Cyc/sec	CircFreq rad/sec	Eigenvalue rad2/sec2
MODAL	Mode	1	0.577088	1.7328	10.888	118.54
MODAL	Mode	2	0.420603	2.3775	14.939	223.16
MODAL	Mode	3	0.37967	2.6339	16.549	273.87
MODAL	Mode	4	0.136163	7.3441	46.145	2129.3
MODAL	Mode	5	0.114558	8.7292	54.847	3008.2
MODAL	Mode	6	0.110647	9.0378	56.786	3224.7
MODAL	Mode	7	0.089641	11.156	70.093	4913
MODAL	Mode	8	0.081306	12.299	77.278	5971.9
MODAL	Mode	9	0.069635	14.361	90.23	8141.4
MODAL	Mode	10	0.065913	15.171	95.325	9086.9
MODAL	Mode	11	0.057814	17.297	108.68	11811
MODAL	Mode	12	0.053002	18.867	118.55	14053

Figure 6: Modal Period and Frequencies

4. Steel Interaction Ratio

Analysis from real time history data have been process which consist of several combination of loading including environmental loads. The other combination was linear analysis considering load cases such as dead load, live load and environmental load.

After run the analysis, the model was checked for Steel Frame Design and Interaction Ratios. Figure 7 shows the value of design interaction ratio that was published by SAP2000 software. Design interaction ratios are varies but all values are lesser than 1.0 which that offshore platform are stable when hit by the earthquake and also other loadings that applied on that structure. The most critical part in the overall system is truss with the ratio of 0.888. The truss are located in the lower side that overall structures. This ratio proved that this offshore platform were in very stable condition. Other element that used for checking are in term of shear forces resistance and also moment resistance of the structure.

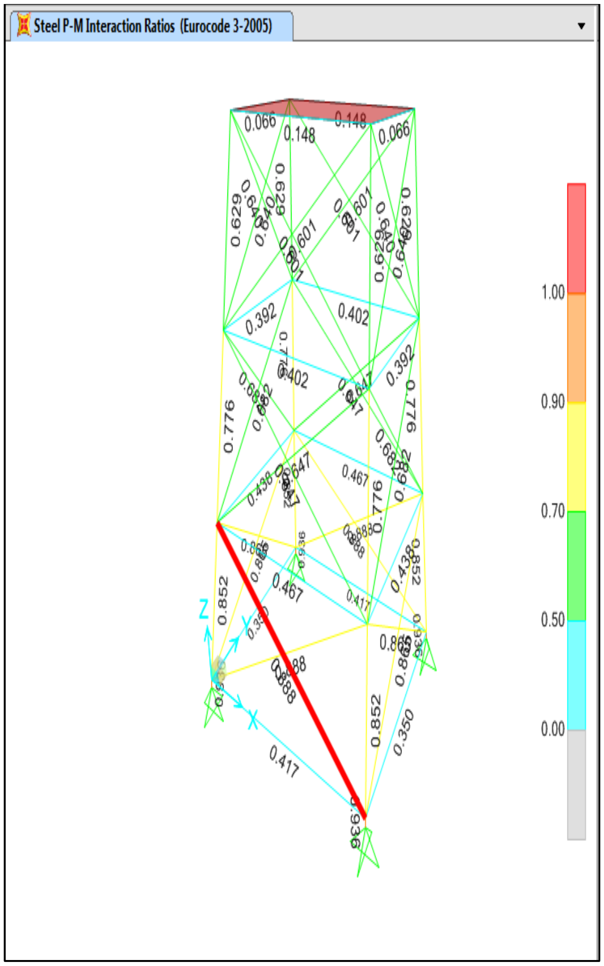

Figure 7: Steel Interaction Ratios

5. Conclusions

Based on the finding research, the structure is adequate to withstand the seismic load. This is because the maximum shear and bending stress is still below the allowable capacity. From the free vibration analysis, the highest value of natural period is 0.577088sec from mode shape 1. The maximum shear and bending are 121.738kN and 995.529kNm occured at element when load combination dead load and live load being applied. The maximum displacement is 17.708mm occured when load combination dead load, live load, environmental load and earthquake load being applied.

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