DETERMINATION OF EARTHQUAKE DESIGN CRITERIA FOR FIXED OFFSHORE PLATFORM (FOUR-LEGGED) DUE TO ACEH EARTHQUAKE IN MALAYSIA

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ABSTRACT

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 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 the offshore structure in Malaysia are not designed to resist seismic loading. The objective of this study is to determine the earthquake design criteria for fixed offshore platform due to Aceh earthquake in Malaysia. The location of the fixed offshore platform is at the Terengganu. 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 are three types of analysis will be carry out: Free vibration analysis, Response spectrum analysis and Time history analysis. For the Free vibration analysis, there would have 12 mode shape of the structure. For the Response spectrum analysis, the analysis will be performed by using response spectra curves of EuroCode8. Time history analysis has been performed by referring to time history earthquake Aceh 2004. The computer software SAP2000 is selected to analyse this structure and the design code for the steel frame is EuroCode3. However, there is an assumption have been made when doing the 3D model of the structure. The fixed offshore platform structure is fixed to the ground instead of pilled and the soil interaction was neglected.

ABSTRAK

Tahap kebimbangan di kalangan jurutera awam di Malaysia mengenai aspek untuk mereka bentuk struktur untuk kriteria reka bentuk gempa bumi adalah rendah. Tetapi terdapat beberapa negara berlaku gempa bumi selalunya seperti Aceh, Indonesia. Sebenarnya gegaran yang berlaku di rantau Malaysia berikutan gempa bumi Aceh dan ia juga terjejas struktur luar pesisir tetap di Malaysia yang struktur luar pesisir di Malaysia tidak direka untuk menahan beban seismik. Objektif kajian ini adalah untuk menentukan kriteria reka bentuk gempa bumi untuk platform luar pesisir tetap akibat gempa bumi Aceh di Malaysia. Lokasi platform luar pesisir yang ditetapkan adalah di Terengganu. Semua faktor-faktor alam sekitar data diberikan seperti julat ketinggian ombak dan pecutan gerakan tanah. The beban alam sekitar seperti ombak dan angin beban telah direka dengan merujuk API (American Petroleum Institute) kriteria reka bentuk. Terdapat tiga jenis analisis akan menjalankan: analisis getaran Percuma, analisis spektrum Respons dan analisis sejarah Time. Untuk analisis getaran Percuma, tidak akan mempunyai bentuk 12 mod struktur. Bagi analisis spektrum Response, analisis akan dilakukan dengan menggunakan lengkung sambutan spektrum EuroCode8. Masa analisis sejarah telah dijalankan dengan merujuk kepada gempa bumi sejarah masa Aceh 2004. perisian komputer SAP2000 dipilih untuk menganalisis struktur ini dan kod reka bentuk untuk kerangka keluli adalah EuroCode3. Walau bagaimanapun, terdapat satu andaian telah dibuat ketika melakukan model 3D struktur. Struktur platform luar pesisir tetap adalah tetap ke tanah bukan pilled dan interaksi tanah telah diabaikan.

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LIST OF SYMBOLS

mm	Millimeter
N/mm^2	Newton per millimeter square
kg	Kilogram
N	Newton
kN	Kilo newton
kN/m^2	Kilo newton per meter square
sec	second
kNm	Kilo newton meter

LIST OF ABBREVIATIONS

BS	British Standard
EN	European Standards
MS	Malaysia Standard
M_L	Local Magnitude Scale
Ms	Surface Wave Magnitude Scale
M_w	Moment Magnitude Scale
API	American Petroleum Institute
MMD	Meteorological Malaysia Department
E	Young Modulus
G	Shear Modulus
DL	Dead Load
LL	Live Load
EL	Environmental Load
TH	Time History
V_{Ed}	Maximum design shear force
$V_{c,Rd}$	Shear resistance
σ_s	Shear stress
$\sigma_{all,s}$	Allowable shear stress
M_{ed}	Maximum external design moment
M_{rd}	Moment resistance
σ_b	Bending stress
$\sigma_{all,b}$	Allowable bending stress

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

In Malaysia, there are several areas that have existing offshore platform structure operate 24 hours all the day. Mostly the existing offshore platform structures are at Terengganu, Sabah and Sarawak. A fixed offshore platform is a large marine structure with facilities to process, extract oil and natural gas, and temporary to store some product such as petroleum until it can bring to shore and run the business. At the Terengganu, Sabah and Sarawak, most of the existing offshore platform structures are owned by PETRONAS. There is the figure that regarding the location of the offshore platform in Malaysia.

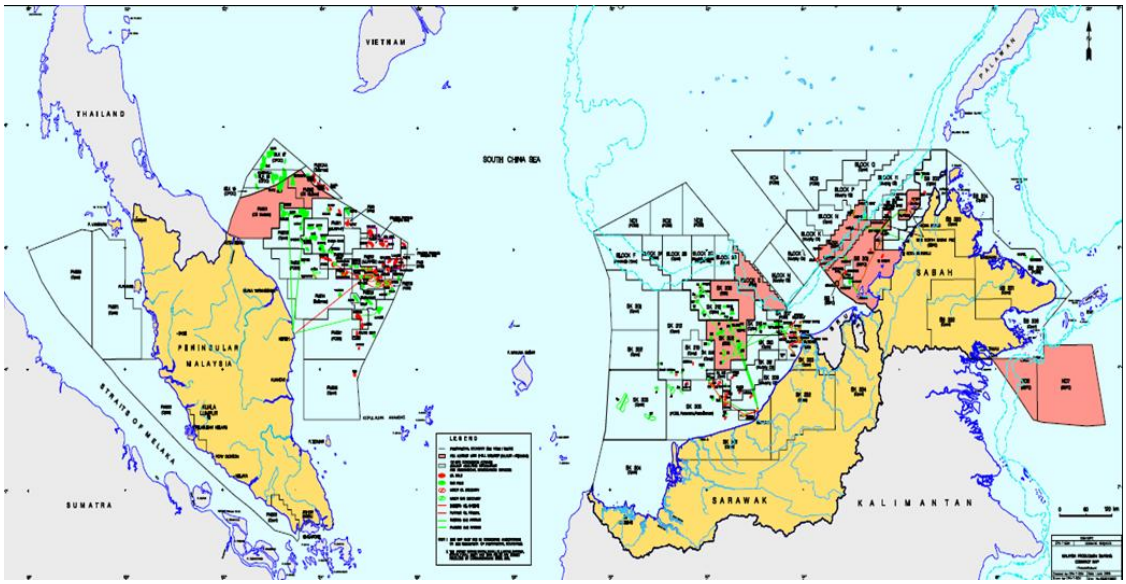

Figure 1.1: Location of the offshore platform in Malaysia

Source: Minyakdangasmalaysia.blogspot.com [Online image]. (2010). Retrieved June 8, 2015 from http://minyakdangasmalaysia.blogspot.com/2010/10/malaysias-oil-gas-maps.html

In Malaysia, there is no any earthquake disaster occur except a few earthquake happened at the Peninsular Malaysia, Sarawak and Sabah. But there is just very small magnitude earthquake. From the USGS record, there are around 500,000 earthquakes occur in each year. Although there is just few small magnitude earthquake in Malaysia region but the nearest country like Indonesia is the country that occur earthquake constantly. The following chapter will discuss about the how the Aceh earthquake affect to Malaysia.

The geologists, scientists and geo-engineers actually can't predict when the earthquakes will happened. Although the professional are already tested different ways of predicting earthquake. Unfortunately, none of them are successful. But, based on

some particular or certain fault, they can analyze where will be another earthquake happen in the future, but there is no other way to know when the earthquake will happen in future. By using the modern seismic code (EuroCode8) to minimize the damage caused by earthquake in future.

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.

1.2 PROBLEM STATEMENT

In this research project, the problem statement is to determine necessary of the seismic hazard consideration for offshore platform (four-legged) in Malaysia region due to Aceh earthquake.

The hazard consideration is needed to take into account because the earthquake from the Aceh was affected the offshore platform structure in Malaysia. Especially the area that's near the country, Indonesia, for example Penang. But the most of the offshore structures get affected at Terengganu, Sabah and Sarawak. Although the building structures inside Malaysia region is safe but it can't ensure that the offshore structure is safe from the large magnitude scale of earthquake, such as Aceh earthquake. As mentioned before, even the specialist scientist also can't predict when the earthquake will occur and earthquake can be happened in anytime and in any place. So, the necessarily to increase the safety factor and design offshore structure with seismic code need to be consider in order to encounter the seismic load.

1.3 RESEARCH OBJECTIVE

The aims of this research are:

i. To estimate the earthquake ground motion due to Aceh earthquake for assessment of offshore platform (four-legged) in Malaysia.

ii. To determine the vulnerability of existing offshore platform (four-legged) in Malaysia when subjected to earthquake load from Aceh

iii. To determine the earthquake design criteria for offshore platform (four-legged) located in Malaysia.

1.4 SCOPE OF STUDY

In the proposed study, the effect of the typical offshore platform due to the Aceh earthquake will be investigated. In this research, the study of the architectural drawing of a typical four-legged fixed offshore platform will be done. The case study will be related to the Aceh earthquake that affected the offshore platform in Malaysia region. The modeling of offshore platform structure and analysis software used is SAP 2000. This research recommended to test the typical offshore platform by using three analyses. There are:

i. Free vibration analysis

ii. Response spectrum earthquake analysis

iii. Time history earthquake analysis

1.5 EXPECTED OUTCOME/S

The expected outcome of the analysis results will show the responses of the fixed offshore platform structure due to Aceh earthquake and all the outcome of the analysis will be done by using analysis software, SAP2000.

1.6 SIGNIFICANCE OF STUDY

The outcomes and findings of this research is to study and analyse the behaviour and stability of 4-legged fixed offshore structures in the Malaysia region due to Aceh earthquake. It may be useful for seismic behaviour assessment of typical fixed offshore platform (four-legged) and contribute to understanding the effect of accounting parameters of seismic performance of existing offshore structure. The analysis results obtained from the earthquake analysis may be used to develop some earthquake design criteria to increase the safety of factor of fixed offshore structure located in Malaysia region to prevent the damage caused from Aceh earthquake.

CHAPTER 2

LITERATURE REVIEW

2.1 EARTHQUAKE

An earthquake is created when the Earth's crust is perform sudden motion. According to geologists, before existence of human, the earth has suffered earthquakes for millions years. When came to the nineteenth century, the geologists started to make the measurement for recording the earthquake data. They collected all the seismological data from many earthquakes and analyzed to map and tried to understand the phenomena of earthquakes. The geologists used these data were to resolve the earth's internal structure and they success to a remarkable degree, which will help towards the development of seismology and to explain the causes of earthquakes. The study of collecting seismological data will also helped in the design of building structure to resist earthquakes. (Datta, 2010)

There is always be the first concerned of safety of the building structure when the earthquake is happening and the seismic load is created to affect the structural design of building. But, the economic loss and serviceability are also of concern. (Ucl.ac.uk, 2015) To understand what the seismic loading is, there is a thing that need to know. The seismic loading is totally different from the gravity loading, it will cause

the different behavior under these two difference loadings. Seismic loading is required more specific detailed analysis to ensure the elastic range is beyond the seismic performance. 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, 2008)

2.2 SEISMIC WAVE

During an earthquake occur, it will released large strain energy and the seismic waves will travel in all directions through the Earth's layers. These seismic waves will refracting and reflecting at each interface. (Ucl.ac.uk, 2015)

2.2.1 Body Waves

Body wave, one of the type of the wave in seismic wave. In the Body wave, there are P-waves and S-waves. Below are the characteristics of the P-waves and S-waves:

2.2.1.1 P-Waves

It is also called Pressure waves or Primary waves. It is longitudinal waves, it is involve in compression and expansion. P-waves is the fastest waves travelling in solids and it is also the first wave appear on a seismogram. It can traveling in both form of material, fluids and solids.

2.2.1.2 S-Waves

It is also called Shear waves or Secondary waves. The type of wave is transverse waves because it moved in perpendicularly to the direction of propagation. In the seismogram, S-waves is appear later after P-waves. And it can only traveling in solids because there is no shear resistances in fluids. This type of waves have the good impact on ground surface movement.

2.2.2 Surface Waves

Surface waves, another type of wave in Seismic waves. In the Surface waves, there are also two categories of waves, there are Love-waves and Rayleigh waves. The description is shown at below:

2.2.2.1 Love-Waves

Love waves are similar to S waves. When the waves are travelling close to the ground surface, they are transverse shear waves.

2.2.2.2 Rayleigh Waves

The Rayleigh wave, the particle motion of these waves is like vertical plane that having the direction of propagation and retrogrades elliptically. This type of wave is moving like the propagation of ocean waves because the biggest displacements of the particle at the surface. Rayleigh waves have the properties that dispersion, its wavelength keep changing and the velocity is not constant. So this type of wave is not stable in acceleration movement. (Ucl.ac.uk, n.d.)

The figure below is to show how the body wave (P-waves and S-waves) and surface wave (Love-waves and Rayleigh waves) moved.

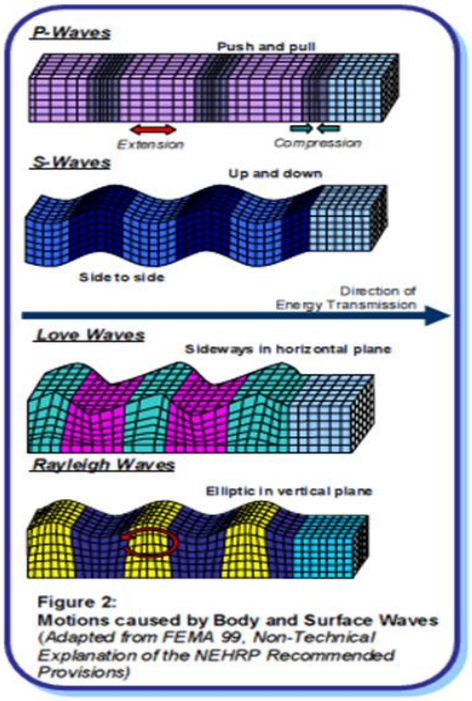

Figure 2.1: Motion of Body and Surface waves

Source: National Information Centre of Earthquake Engineering [Online image]. (2005). Retrieved September 13, 2014, from http://nicee.org/EQTips.php

2.3 CAUSES OF EARTHQUAKE

2.3.1 Plate Tectonics

The plate tectonics is actually regarding of continental drift. The existence natural phenomena like seamounts, island areas, transform faults, and orogenic zones made the theory of continental drift. The continental motions are related with differences of circulation patterns. So, the continental motion does not move as a body,

it is moving or occurs through the sliding of the lithosphere in pieces, it called tectonic plates. There are seven major tectonic plates, as shown in Figure 3.

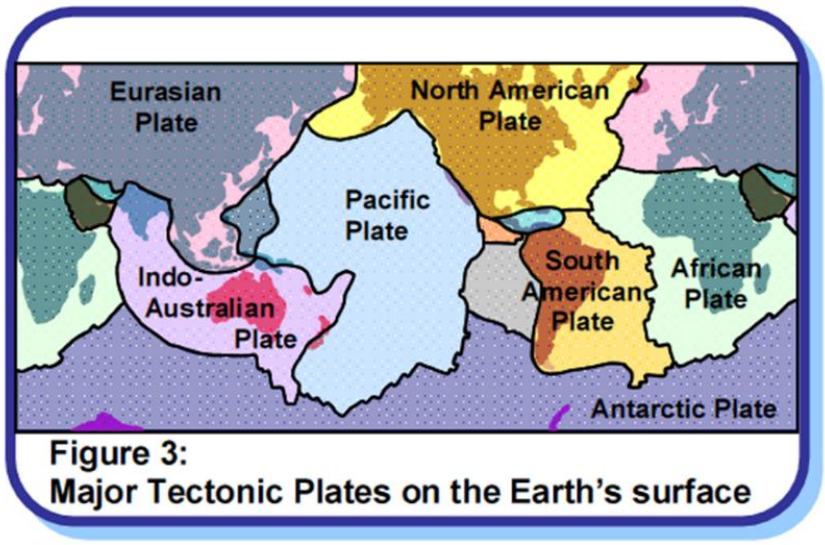

Figure 2.2: Seven major tectonic plates

Source: National Information Centre of Earthquake Engineering [Online image]. (2005). Retrieved September 23, 2014 from http:// nicee.org/EQTips.php

The tectonic plates are moving relative to each other, it can be move in both of direction and magnitude, both at the plate boundaries, inside the plates and leads to an accumulation of strain. The plates accumulates the strain energy will overcome any resistance and causes slip between the two sides of the fault. Because of the sudden slip, it release large amounts of energy and causing elastic rebound, which constitutes or is the earthquake. (Tze Khai, 2008)

2.3.2 Fault

The plate boundaries at the location of earthquake occur are called fault. This type of earthquakes are in terms of interpolate earthquakes. When the earthquakes occur within the plate away from the faults, this type of earthquake are called intraplate earthquakes. Which sudden release of energy because of rock beds are slips together. These slips creating the new faults are called earthquake faults. There are the typical terms to describe different types of faults:

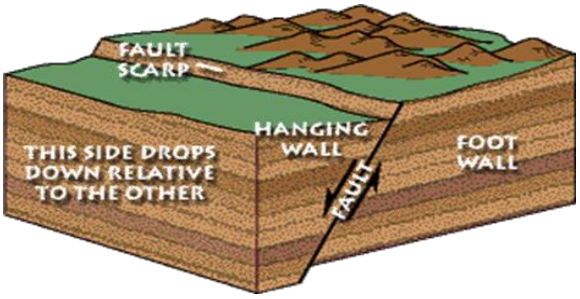

Figure 2.3: Normal fault

Source: National Information Centre of Earthquake Engineering [Online image]. (2005). Retrieved September 23, 2014, from http:// nicee.org/EQTips.php

Normal fault: When two sides of rock beds move away from each other in tension.

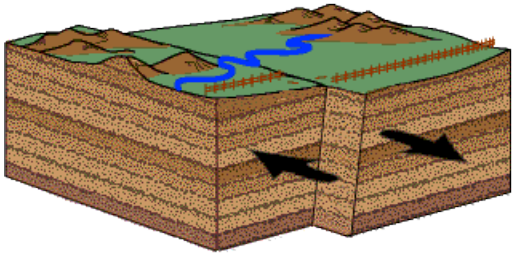

Figure 2.4: Strike-slip fault

Source: National Information Centre of Earthquake Engineering [Online image]. (2005). Retrieved September 23, 2014 from http:// nicee.org/EQTips.php

Strike-slip fault: When the rock beds moved parallel to the strike of the fault.

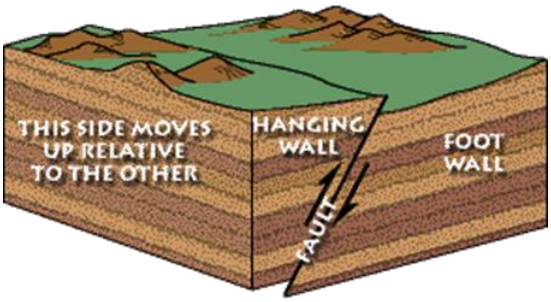

Figure 2.5: Reverse fault

Source: National Information Centre of Earthquake Engineering [Online image]. (2005). Retrieved September 23, 2014 from http:// nicee.org/EQTips.php

Reverse fault: When two bed rocks are compressed to move towards each other (Chen & Scawthorn, 2003)