CRITICAL MEMBER ANALYSIS OF WELLHEAD OFFSHORE PLATFORM DUE TO EL CENTRO EARTHQUAKE

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B. ENG(HONS.) CIVIL ENGINEERING

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SUPERVISOR’S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the Bachelor Degree in Civil Engineering.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_________________________________
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CRITICAL MEMBER ANALYSIS OF WELLHEAD OFFSHORE DUE TO AL CENTRO EARTHQUAKE

LENG YEE HUI

Thesis submitted in fulfillment of the requirements for the award of the Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2018
DEDICATION

This thesis is proudly dedicated to

My beloved parent
Leng So Hua and Yeoh Ley Peng
For their great support, pray, love and care

My supervisor
Ir. Dr. Saffuan
For his excellent guidance, advice, and motivation

Making me who I am today
I would like to take this opportunity to thank my university, University Malaysia Pahang for providing me the good condition of facilities and equipment to complete this study.

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ABSTRAK

ABSTRACT

The paper deals with the seismic analysis of a critical member of wellhead offshore platform in Malaysia with the aim to compute the response and assess the resistance capacity of the structure to earthquake loading. However, the boundary condition of the offshore structure is assumed as fixed to the ground and soil interaction has been neglected. This study is conducted due to tremors occurred in Malaysia caused by Sumatra and Philippine earthquakes have been reported several times. Thus, engineers are concerned about the seismic vulnerability of offshore structures due to lack of earthquake consideration in Malaysia’s building design procedure. With this, wellhead offshore platform is analyzed using Finite Element Modelling (FEM) by SAP2000 software under different types of analyses including Free Vibration Analysis (FVA), Response Spectrum (RS) by using response spectra curves of Eurocode 8 and Time History Analysis (THA) considering El Centro 1940 earthquake data. The design code for the steel frame is Eurocode 3. All the environmental factors data are given such as ranges of wave height, wave period, current velocity and ground motion acceleration. The environmental loadings such as wave and wind load have been designed by referring API (American Petroleum Institute) design criteria. In conclusion, wellhead offshore platform is stable and capable to withstand the earthquake. It can be concluded that the design of the offshore structures can provide sufficient resistance against seismic effects and most of the part of the structure was in good condition.
# TABLE OF CONTENT

DECLARATION

TITLE PAGE

DEDICATION

ACKNOWLEDGEMENTS

ABSTRAK

ABSTRACT

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

LIST OF ABBREVIATIONS

CHAPTER 1 INTRODUCTION

1.1 Background of Study

1.2 Problem Statement

1.3 Objectives

1.4 Scope of Study

1.5 Significance of Study

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

2.2 Earthquake

2.2.1 Plates Tectonics Theory
2.2.2 Fault
2.2.3 Seismic Waves
2.2.4 Earthquake Measurement

2.3 El Centro Earthquake, 1940

2.4 Seismicity in Malaysia

2.5 Offshore Structure
2.5.1 Offshore Wellhead Platform Support Frame

2.6 Code of Practices for Offshore Structure
2.6.1 Seismic Design Guideline
2.6.2 Environmental Load Design Guideline
2.6.3 Structural Design Guideline for Steel Structure

2.7 Design Criteria for Offshore Structure
2.7.1 Dead Load
2.7.2 Live Load
2.7.3 Wind Load
2.7.4 Waves Load
2.7.5 Current Load
2.7.6 Earthquake Load

2.8 Seismic Response of the Structure

CHAPTER 3 METHODOLOGY

3.1 Planning of Study
3.2 Information and Data Collection
3.2.1 Detailing Description
3.2.2 Material Description
3.2.3 Loads Description
CHAPTER 4 RESULTS AND DISCUSSION

4.1 Summary of Analysis

4.2 Wellhead Offshore Modelling

4.3 Free Vibration Analysis

4.4 Time History Analysis

4.5 Response Spectrum Analysis

4.6 Linear Analysis

4.7 Result Comparison of SAP 2000 and Manual Calculation

4.8 Summary of Analysis

CHAPTER 5 CONCLUSION

5.1 Conclusion

5.2 Recommendations

REFERENCES

APPENDIX A Grid system data

APPENDIX B Modal Shape of offshore platform

APPENDIX C Manual Calculation
LIST OF TABLES

Table 2.1  Richter scale  
Table 2.2  Modified Mercalli intensity (MMI) scale  
Table 2.3  Local earthquake occurrences in Malaysia  
Table 2.4  Result of dynamic response from different input in the analysis  
Table 3.1  Dead loads and live load description  
Table 3.2  Environmental criteria used at Terengganu  
Table 3.3  Shape Coefficient, $C_s$  
Table 3.4  Drag coefficient, $C_d$ and Inertia Coefficient, $C_m$  
Table 3.5  Imperfection factors fro buckling factors, $\alpha$  
Table 4.1  Modal period and frequencies  
Table 4.2  Time History Displacement, Velocities, and Acceleration of Joint 37 in 3 directions  
Table 4.3  Shear force diagram for several load combination at element 25  
Table 4.4  Shear stress and allowable capacity check for several load combination at element 25  
Table 4.5  Bending moment diagram for several load combination at element 25  
Table 4.6  Bending stress and allowable capacity check for several load combination at element 25  
Table 4.7  PMM Demand/Capacity Ratio between manual calculation and SAP2000  
Table 4.8  Unity Ratio of Structure Member  
Table 4.9  Joint Displacement in different load combination at joint 37  
Table 4.10  Joint Velocities in different load combination at joint 37  
Table 4.11  Joint Acceleration in different load combination at joint 37
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Gross Domestic Products First Quarter 2018</td>
<td>1</td>
</tr>
<tr>
<td>1.2</td>
<td>Relationship of crude oil to other fossil fuels</td>
<td>2</td>
</tr>
<tr>
<td>1.3</td>
<td>a) Onshore drilling and b) offshore drilling</td>
<td>3</td>
</tr>
<tr>
<td>1.4</td>
<td>Plate Tectonic</td>
<td>4</td>
</tr>
<tr>
<td>1.5</td>
<td>Earthquake-prone region of Malaysia</td>
<td>5</td>
</tr>
<tr>
<td>2.1</td>
<td>General illustration of an earthquake rupture scenario</td>
<td>10</td>
</tr>
<tr>
<td>2.2</td>
<td>Inner earth</td>
<td>11</td>
</tr>
<tr>
<td>2.3</td>
<td>Major Plates</td>
<td>11</td>
</tr>
<tr>
<td>2.4</td>
<td>Conventional current below Earth</td>
<td>12</td>
</tr>
<tr>
<td>2.5</td>
<td>Types of interplates boundaries</td>
<td>13</td>
</tr>
<tr>
<td>2.6</td>
<td>Types of fault</td>
<td>14</td>
</tr>
<tr>
<td>2.7</td>
<td>Seismic wave types</td>
<td>16</td>
</tr>
<tr>
<td>2.8</td>
<td>Strong motion record from El Centro, 1940.</td>
<td>21</td>
</tr>
<tr>
<td>2.9</td>
<td>The collapse of these walls in the business district of Imperial caused the deaths of four people.</td>
<td>22</td>
</tr>
<tr>
<td>2.10</td>
<td>The collapse of the 100,000 gallon city water tank at Imperial.</td>
<td>22</td>
</tr>
<tr>
<td>2.11</td>
<td>Earthquake hazard zonation</td>
<td>25</td>
</tr>
<tr>
<td>2.12</td>
<td>Type of offshore structure</td>
<td>27</td>
</tr>
<tr>
<td>2.13</td>
<td>Fixed offshore platform</td>
<td>28</td>
</tr>
<tr>
<td>2.14</td>
<td>Seismic design procedure</td>
<td>31</td>
</tr>
<tr>
<td>2.15</td>
<td>Loads on offshore platform. (V, self-weight of topside; Mv, moment with eccentric loading of platform; Lb, lateral wind load; Lc, lateral current load; Lw, lateral wave load, Mb &amp; Mc &amp; Mw, moment related to lateral loadings, and E, seismic load)</td>
<td>33</td>
</tr>
<tr>
<td>2.16</td>
<td>Waves characteristic</td>
<td>35</td>
</tr>
<tr>
<td>2.17</td>
<td>Damped and undamped oscillations</td>
<td>38</td>
</tr>
<tr>
<td>3.1</td>
<td>Flow Chart of Methodology</td>
<td>42</td>
</tr>
<tr>
<td>3.2</td>
<td>Side view of wellhead support frame</td>
<td>44</td>
</tr>
<tr>
<td>3.3</td>
<td>Plan view of wellhead support frame</td>
<td>44</td>
</tr>
<tr>
<td>3.4</td>
<td>Data of material properties</td>
<td>45</td>
</tr>
<tr>
<td>3.5</td>
<td>Transferring earthquake data from East direction in MS Excel</td>
<td>50</td>
</tr>
<tr>
<td>3.6</td>
<td>Time (s) vs Acceleration (g) in E-direction</td>
<td>50</td>
</tr>
<tr>
<td>3.7</td>
<td>Selection of buckling curve for a cross section</td>
<td>55</td>
</tr>
<tr>
<td>3.8</td>
<td>Select the modal type and unit</td>
<td>57</td>
</tr>
</tbody>
</table>
Figure 3.9  Define grid system data  
Figure 3.10 Define material types  
Figure 3.11 Material properties data  
Figure 3.12 Define pipe section  
Figure 3.13 3D modelling of the structure  
Figure 3.14 Restraint at the base  
Figure 3.15 Define load pattern for each loading  
Figure 3.16 Define all load cases  
Figure 3.17 Dead load & live load  
Figure 3.18 Dead load case data  
Figure 3.19 Live load case data  
Figure 3.20 Wind load pattern data  
Figure 3.21 Wind load case data  
Figure 3.22 Wave load pattern  
Figure 3.23 Wave characteristics  
Figure 3.24 Current profile data  
Figure 3.25 Wave plot  
Figure 3.26 Wave load case data  
Figure 3.27 Define time history function  
Figure 3.28 Linear modal history case data  
Figure 3.29 Response spectrum EuroCode 8 function  
Figure 3.30 Response spectrum load case data  
Figure 3.31 Modal load case  
Figure 3.32 Define load combination  
Figure 3.33 Set load case to run  
Figure 3.34 Result output table  
Figure 4.1 3D model of the wellhead support frame  
Figure 4.2 Modal periods  
Figure 4.3 Three modes of vibration (a) mode shape 1 (0.1060 sec) (b) mode shape 2 (0.0878 sec) (c) mode shape 3 (0.0776 sec)  
Figure 4.4 Time (sec) versus Acceleration (g)  
Figure 4.5 Comparison of displacement history in x, y and z direction at Joint 37  
Figure 4.6 Comparison of velocity history in x, y and z direction at Joint 37  
Figure 4.7 Comparison of acceleration history in x, y and z direction at Joint 37  
Figure 4.8 Pseudo Spectral Acceleration in x, y and z direction at Joint 37
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.9</td>
<td>PMM Demand/Capacity Ratio of Wellhead Offshore Structure</td>
<td>89</td>
</tr>
<tr>
<td>4.10</td>
<td>Graph of Bending Stress versus Load Cases</td>
<td>98</td>
</tr>
<tr>
<td>4.11</td>
<td>Graph of Shear Stress versus Load Cases</td>
<td>98</td>
</tr>
<tr>
<td>4.12</td>
<td>Graph of Joint Displacement versus Load Cases in Three Directions</td>
<td>99</td>
</tr>
<tr>
<td>4.13</td>
<td>Graph of Joint Velocities versus Load Cases in Three Directions</td>
<td>100</td>
</tr>
<tr>
<td>4.14</td>
<td>Graph of Joint Acceleration versus Load Cases in Three Directions</td>
<td>101</td>
</tr>
<tr>
<td>4.15</td>
<td>Deformed shape of DL + LL</td>
<td>101</td>
</tr>
<tr>
<td>4.16</td>
<td>Deformed shape of EL</td>
<td>102</td>
</tr>
<tr>
<td>4.17</td>
<td>Deformed shape of DL + LL + EL + TH_AC</td>
<td>102</td>
</tr>
<tr>
<td>4.18</td>
<td>Deformed shape of RS</td>
<td>103</td>
</tr>
<tr>
<td>Symbol</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------</td>
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</tr>
<tr>
<td>km</td>
<td>kilometer</td>
<td></td>
</tr>
<tr>
<td>cm/yr</td>
<td>centimeter per year</td>
<td></td>
</tr>
<tr>
<td>m/s²</td>
<td>metre per square second</td>
<td></td>
</tr>
<tr>
<td>Hz</td>
<td>hertz</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>meter</td>
<td></td>
</tr>
<tr>
<td>Nm</td>
<td>Newton meter</td>
<td></td>
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<tr>
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<td>Millimetre</td>
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</tr>
<tr>
<td>N</td>
<td>Newton</td>
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</tr>
<tr>
<td>Kg/m³</td>
<td>kilogram per cubic meter</td>
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</tr>
<tr>
<td>m/s</td>
<td>meter per second</td>
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<tr>
<td>m²</td>
<td>square meter</td>
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<tr>
<td>MPA</td>
<td>Mega Pascal</td>
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<tr>
<td>G</td>
<td>Gal</td>
<td></td>
</tr>
<tr>
<td>Hz</td>
<td>Hertz</td>
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<tr>
<td>N/m³</td>
<td>Newton per cubic meter</td>
<td></td>
</tr>
<tr>
<td>MN</td>
<td>Mega newton</td>
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<tr>
<td>s</td>
<td>second</td>
<td></td>
</tr>
</tbody>
</table>
# LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>BS</td>
<td>British Standard</td>
</tr>
<tr>
<td>EC</td>
<td>Eurocode</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>API</td>
<td>American Petroleum Institute</td>
</tr>
<tr>
<td>P</td>
<td>Primary</td>
</tr>
<tr>
<td>S</td>
<td>Secondary</td>
</tr>
<tr>
<td>L</td>
<td>Love</td>
</tr>
<tr>
<td>R</td>
<td>Rayleigh</td>
</tr>
<tr>
<td>$v$</td>
<td>Poisson’s ratio</td>
</tr>
<tr>
<td>$E$</td>
<td>Young’s modulus</td>
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<tr>
<td>$G$</td>
<td>Shear modulus</td>
</tr>
<tr>
<td>$P$</td>
<td>Density</td>
</tr>
<tr>
<td>$M_l$</td>
<td>Local magnitude</td>
</tr>
<tr>
<td>$m_b$</td>
<td>Body wave magnitude</td>
</tr>
<tr>
<td>$A$</td>
<td>Maximum amplitude (in microns)</td>
</tr>
<tr>
<td>$T$</td>
<td>Period (in seconds)</td>
</tr>
<tr>
<td>$M_s$</td>
<td>Surface wave magnitude</td>
</tr>
<tr>
<td>$M_w$</td>
<td>Moment magnitude</td>
</tr>
<tr>
<td>$A$</td>
<td>Fault area</td>
</tr>
<tr>
<td>$U$</td>
<td>Longitudinal displacement of fault (in m)</td>
</tr>
<tr>
<td>$M_o$</td>
<td>Seismic moment (in Nm)</td>
</tr>
<tr>
<td>MMI</td>
<td>Modified Mercalli Intensity</td>
</tr>
<tr>
<td>PGA</td>
<td>Peak ground acceleration</td>
</tr>
<tr>
<td>PGV</td>
<td>Peak ground velocity</td>
</tr>
<tr>
<td>US</td>
<td>United State</td>
</tr>
<tr>
<td>ATC</td>
<td>Applied Technology Council</td>
</tr>
<tr>
<td>FPU</td>
<td>Floating production unit</td>
</tr>
<tr>
<td>FPSO</td>
<td>Floating production, storage and offloading</td>
</tr>
<tr>
<td>DLE</td>
<td>Ductility Level Earthquake</td>
</tr>
<tr>
<td>PSHA</td>
<td>Probabilistic Seismic Hazard Assessment</td>
</tr>
<tr>
<td>DSHA</td>
<td>Deterministic Seismic Hazard Assessment</td>
</tr>
<tr>
<td>CEN</td>
<td>European Committee for Standardization</td>
</tr>
<tr>
<td>ELE</td>
<td>Extreme level Earthquake</td>
</tr>
<tr>
<td>ALE</td>
<td>Abnormal Level Earthquake</td>
</tr>
<tr>
<td>ULS</td>
<td>Ultimate limit state</td>
</tr>
<tr>
<td>V</td>
<td>Self-weight of topside</td>
</tr>
<tr>
<td>$M_v$</td>
<td>Moment with eccentric loading of platform</td>
</tr>
<tr>
<td>$L_b$</td>
<td>Lateral wind load</td>
</tr>
<tr>
<td>$L_c$</td>
<td>Lateral current load</td>
</tr>
<tr>
<td>$L_w$</td>
<td>Lateral wave load</td>
</tr>
<tr>
<td>$M_b$</td>
<td>Moment related to wave loadings</td>
</tr>
<tr>
<td>$M_c$</td>
<td>Moment related to current loadings</td>
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<tr>
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<td>Moment related to wind loadings</td>
</tr>
<tr>
<td>$D$, $\varnothing$</td>
<td>Diameter</td>
</tr>
<tr>
<td>$L$</td>
<td>Length</td>
</tr>
<tr>
<td>$\omega$</td>
<td>Circular frequency (in rad/sec)</td>
</tr>
<tr>
<td>$f$</td>
<td>Number of vibration (Hertz or cycle/sec)</td>
</tr>
</tbody>
</table>
Time required to complete one cycle of vibration

Wall thickness

Design wind speed

Height above sea level

1 hour mean wind speed

Turbulence intensity

Wind drag force

Density of air

Wind speed

Shape coefficient

Area of object

Hydrodynamic force vector per unit length

Drag force per unit length

Drag coefficient

Inertia coefficient

Maximum horizontal particle velocity at storm mean water level

Apparent wave period

Platform leg diameter at storm mean water level

Gravity acceleration

Free vibration analysis

Dead load

Live load

Environmental load

Time history

Response spectrum

Yield strength

Ultimate strength

Partial factor

Plastic section modulus

Design bending resistance

Design plastic bending resistance

Design shear resistance

Design plastic shear resistance

Reduction factor for bucking mode

Non-dimensional slenderness

Relative slenderness

Strain

Buckling length

Radius of gyration

Imperfection factor

Design shear force

Shear stress

Allowable shear force

Allowable shear stress

Design moment

Bending stress

Allowable bending moment

Allowable bending stress
CHAPTER 1

INTRODUCTION

1.1 Background of Study

Malaysia is the third-largest exporter of liquefied natural gas in the world and the second largest oil and natural gas manufacturer in Southeast Asia (US. Energy, Information Administration, 2011). In spite of the low price of global crude oil, Oil and Gas sector is still playing a crucial role in our country because it subsidizes around 20 to 30 % to the Gross Domestic Product (GDP) in Malaysia. It recognized as an important and priority sector by Petrolashion Nasional Bhd (PETRONAS, the National Oil Company) and Malaysia’s Government due to the massive multiplier effect developed by this sector with more than 3,500 companies that work in oil and gas (O&G) in Malaysia (PWC, 2016). This showed that the petroleum industry is still a major element of the worldwide economy.

Figure 1.1 Gross Domestic Products First Quarter 2018
Sources: Department of Statistic Malaysia, 2018

The processes involved in petroleum industry are exploration, extraction, refining, transporting, and marketing of petroleum product. Petroleum, as known as
crude oil and natural gas which are a mixture of hydrocarbon molecules that made up by the dead bodies of plants and animals, mostly was the small marine life that had lived millions of years ago. Basically, these petroleum reservoirs are located at thousands of feet below the surface. Hence, drilled wells are required to install to the reservoirs in order to reveal or determine oil and gas for multiple functions development and economic uses. Generally, one or more exploratory wells and several development wells may require for a sizable petroleum reservoir. An exploratory well is to identify petroleum reservoir purposes while development well is to manufacture discovered oil and gas. Oil and gas reserves is the volumes of oil and gas discovered within the petroleum reservoir (Light, 2011).

![Diagram of hydrocarbon conversion](image)

**Figure 1.2** Relationship of crude oil to other fossil fuels

Sources: (Speight, 2015)

There are two advanced drilling techniques for oil and gas: offshore drilling and onshore drilling. Onshore drilling indicates that the deep holes are drilling under the earth’s surface while offshore drilling refers to drilling underneath the seabed. In term of cost, onshore drilling will be more economical than offshore drilling as the timeline of the contract is often shorter. However, offshore drilling is adopted in Malaysia as most of the reserves are discovered beneath the seabed (US. Energy, Information Administration, 2011). Unlike onshore drilling, offshore drilling will be facing more challenges on the stability issues due to the shear depth of water before reaching the seabed. Hence, the platform must remain stable and secure by facilitating some anchoring to the ocean floor. These platforms use either in the fixed or floating platform.
The types of offshore drilling platforms including fixed platform, compliant towers, sea star, floating production system, tension leg platform, subsea platform and SPAR platform (Devold, 2002).

![Figure 1.3](a) Onshore drilling and b) offshore drilling

Sources: Devold, 2002; Speight, 2015

The design lifetime of the offshore structures must be at least 25 years or more depending on the reservoir capacity. Offshore platforms are either constructed in huge steel or concrete structures to explore and extract the oil and gas from the petroleum reservoir. In terms of the response of the structure and loading system, it leads to the construction of offshore structures is more complicated compared with onshore structures. This is because of the high level of uncertainties and high dependency on the environment condition that increases the complexity of design and construction process as the offshore structure used have been extended from shallow to deep water (Mukhlas et al., 2016). This is the most challenging and inventive task for the engineers to design the best offshore structure platform that is reconcilable with that tremendous environmental condition (A S Kharade; and S V Kapadiya, 2014).

However, there are some design considerations that are crucial for engineers to be taken humourlessly such as the peak loads created by cyclone wind, strong waves and seismic load as well. According to Marto, Tan, Kasim, & Mohd.Yunus, (2013), although Malaysia is considered as relatively low seismicity but it is important for engineers to take into account to the design as Malaysia is bordered by the most two seismically active plate boundaries which are on the west and east from the inter-plate boundary between the Indo-Australian and Eurasian Plates and the inter-plate boundary...
REFERENCES


