THE EARTHQUAKE EFFECT OF DOUBLE STOREY STEEL STRUCTURE DUE TO ACEH EARTHQUAKE

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SITI HAJAR BINTI SA'ADIN

Thesis submitted in partial fulfilment of the requirements
for award of the degree of
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JUNE 2016

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TABLE OF CONTENT

CHAPTER 4 RESULT AND DISCUSSION

CHAPTER 5 CONCLUSION

LIST OF TABLE

LIST OF FIGURE

LIST OF SYMBOLS

km	Kilometer
s	Second
ML	Local Magnitude
A	Maximum Trace Amplitude for a Given Earthquake at a Given Distance
A_0	Amplitude for a Particular Earthquake Selected as Reference
Fr	Residual Stress
Fy	Axial Tensile Yield Stress
kg	Kilogram
kN	KiloNewton
mm	Millimeter
E	Young Modulus
G	Shear Modulus
v	Poisson’s Ration
α	Coefficient of Thermal Expansion
C	Celsius
Gk	Dead Load
Qk	Live Load
EQk	Earthquake Load
RS1k	Response Spectrum U1 Load
RS2k	Response Spectrum U2 Load
TH1k	Time History U1 Load
TH2k	Time History U2 Load
T	Period

f	Frequency
V_{Ed}	Design Shear Force
M_{Ed}	Maximum External Design Moment

LIST OF ABBREVIATION

CEN	European Committee for Standardization
EN	European Standard
ULS	Ultimate Limit State
DLS	Damage Limitation State
RF	Rossi-Forel
MMI	Modified Mercalli Intensity
P	Primary
S	Secondary
USGS	United State Geology Survey
MRF	Moment Resisting Frames
CBF	Frames With Concentric Bracings
EBF	Frames With Eccentric Bracings
2D	Two Dimensional
3D	Three Dimensional
MMD	Malaysian Meteorological Department
U1	Unit Translational Acceleration in X Direction
U2	Unit Translational Acceleration in Y Direction
U3	Unit Translational Acceleration in Z Direction
TH	Time History
RS	Response Spectrum
DL	Dead Load
LL	Live Load
EL	Earthquake Load

N	North
E	East

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ABSTRACT

This research refers to the seismic behaviour of double storey steel structure due to Aceh Earthquake. Nowadays, steel structures are widely used all around the world. However, seismic design were not concerned by Civil Engineers in Malaysia almost in all of the building. Recently, few earthquake start occurring in few regions in Malaysia and neighbouring country like Indonesia and Philippines. The tremors occur in this neighbouring country affect the steel structure in Malaysia which the steel structural in Malaysia are not design to resist seismic loading. The objective of this study is to model and analyses the steel structure subjected to different earthquake loads in SAP 2000 program and to determine the best mode shape of free vibration analysis. Besides that, this research also to study the behaviour of double storey steel structure that subjected to different earthquake loading and to determine the performance of double storey steel structure under different earthquake loadings. The earthquake load are analysed accordance to Eurocode 8 and the steel structure are analysed accordance to Eurocode 3. There are four types of analysis that will be carry out which is Free Vibration Analysis, Linear Static Analysis, Response Spectrum Analysis and Time History Analysis. The 12 mode shape with the period and frequency are obtained from Free Vibration Analysis. From Static Analysis, Response Spectrum Analysis and Time History Analysis, the displacement, shear force and bending moment is obtained. The Response Spectrum Analysis provides insight into dynamic behaviour by measuring pseudo-spectral acceleration, velocity, or displacement as a function of structural period for a given time history and level of damping. The percentage of damping used in Malaysia is a damping of 0.05 (5%). Time history analyses the structural response which is computed at a number of subsequent time instants. Time History analysis are performed using the data of earthquake that occur in Aceh in 2004. The software program SAP 2000 is chosen to analyses this steel structure. Several items are studied and analysed by comparing the results generated by the models using a computer program, SAP 2000 in each analysis. However, the simulation of the model of the steel structure is not similar to the condition of the actual structure which is there is no consideration of pile-soil interaction and connection of the steel structure.

ABSTRAK

Kajian ini merujuk kepada tingkah laku seismik ke atas struktur keluli dua tingkat akibat Gempa Bumi dari Aceh. Pada masa kini, struktur keluli digunakan secara meluas di seluruh dunia. Walau bagaimanapun, reka bentuk seismik tidak diambil berat oleh Jurutera Awam di Malaysia hampir di semua bangunan. Baru-baru ini, beberapa gempa bumi mula berlaku di beberapa kawasan di Malaysia dan negara jiran seperti Indonesia dan Filipina. Gegaran berlaku di negara jiran ini memberi kesan kepada struktur keluli di Malaysia di mana struktur keluli di Malaysia tidak direka bentuk untuk menentang beban seismik. Objektif kajian ini adalah untuk memodel dan menganalisis struktur keluli tertakluk kepada beban gempa bumi yang berbeza dalam program SAP 2000 dan untuk menentukan bentuk mod yang terbaik dalam analisis getaran bebas. Selain daripada itu, kajian ini juga untuk mengkaji tingkah laku struktur keluli dua tingkat yang dikenakan bebanan gempa bumi yang berbeza dan untuk menentukan prestasi struktur keluli dua tingkat di bawah beban gempa bumi yang berbeza. Beban gempa bumi dianalisis mengikut Eurocode 8 dan struktur keluli dianalisis mengikut Eurocode 3. Terdapat empat jenis analisis yang akan dijalankan iaitu yang Analisis Getaran Bebas, Analisis Statik Lurus, Analisis Tindakbalas Spektra dan Analisis Masa Sejarah. 12 bentuk mod dengan tempoh dan kekerapan diperolehi daripada Analisis Getaran Bebas. Dari Analisis Statik, Analisis Tindakbalas Spektra dan Analisis Masa Sejarah, anjakan, daya ricih dan momen lentur diperolehi. Analisis Tindakbalas Spektra memberikan pandangan ke dalam tingkah laku dinamik dengan mengukur pecutan pseudo-spektra, halaju, atau anjakan sebagai fungsi tempoh struktur dalam satu masa sejarah yang diberikan dan tahap redaman. Peratusan redaman yang digunakan di Malaysia ialah redaman 0.05 (5%). Masa sejarah menganalisis tindak balas struktur yang dikira di beberapa masa segera berikutnya. Analisis Sejarah Masa dijalankan dengan menggunakan data gempa bumi yang berlaku di Aceh pada tahun 2004. Program perisian SAP 2000 dipilih untuk menganalisis struktur keluli ini. Beberapa item dikaji dan dianalisis dengan membandingkan keputusan yang dihasilkan oleh model menggunakan program komputer, SAP 2000 dalam setiap analisis. Walau bagaimanapun, simulasi model struktur keluli tidak sama dengan keadaan struktur sebenar iaitu tiada pertimbangan mengenai interaksi antara tanah dan cerucuk dan sambungan antara struktur keluli.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Earthquake is a movement of the surface of earth due to internal energy from the core of earth at a sudden that may cause the building to collapse and the death of thousands of people. The main cause of earthquake is the orogenic movements such as mountain building and valley farming, subduction and plate convection followed by geothermal and mechanical disturbances and volcanic activities and land erosion.

On past few years, Malaysia was only having a small earthquake in some place which does not has much effect on the building. However, Malaysia is affected by the earthquake from another country in seismically active plate boundaries from Indonesia and Philippines. On 2015, Malaysia had face the biggest damage due to earthquake in Ranau, Sabah with magnitude of 6.0 Richter scale followed by smaller magnitude for several times. The earthquakes in Sabah are reportedly occurring due to plate convection which Sabah before was away from the boundary.

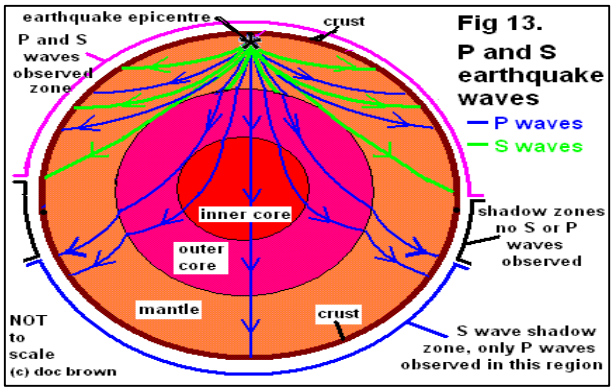

Figure 1.1: Seismic Shock Wave

(http://www.docbrown.info/page21/GeoChangesANS07.htm)

The core of the Earth is very hot. The heat source is thought to be left over from the formation of this planet a few billion years ago. Heat is also generated by tidal forces between the Earth, Moon, and Sun, the decay of radioactive elements, and other resources may not yet be determined. Figure below is about plate tectonics model explains many aspects of geometry continents and ocean basins and the process of creating new oceanic and continental crust.

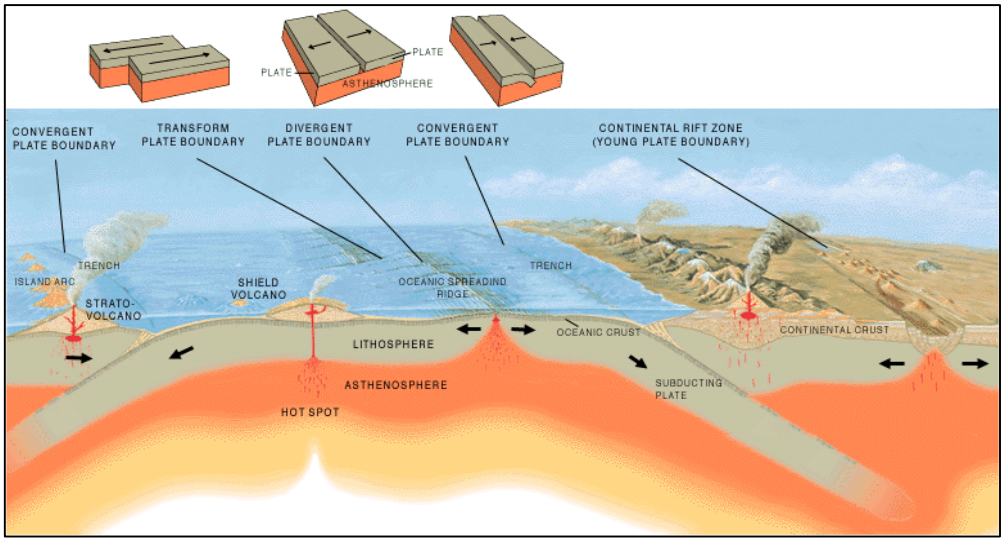

Figure 1.2: Plate Tectonics Model

(http://pubs.usgs.gov/gip/earthq1/plate.html)

1.2 PROBLEM STATEMENT

In Malaysia, almost all building was not design with seismic criteria design which might affect the future of this building. Lately in Malaysia a small value of Richter scale already occur in some place for example in Bukit Tinggi in 2007 with 3 magnitude which there is not much of damage. The latest one occurs in Ranau, Sabah with highest magnitude of 6.0 that cause a big damage and death.

In this research, the problem statement is to determine the necessary of the seismic hazard consideration for steel structure in Malaysia region due to earthquake in Aceh. Although the building structures in Malaysia region is safe but it won't ensure that the structure is safe from the large magnitude scale of Earthquake that might occur anytime. There it is necessary to consider the seismic design code in structure to increase safety in encounter the seismic load.

There are four sorts of plate boundaries which is divergent, convergent, transform, and plate boundary zone. Divergent boundaries are the place new outside layer is delivered as plates draw far from one another. Convergent boundaries are where hull is pulverized as one plate jumps under another. Transform boundaries where outside is not made or pulverized as the plates slide evenly past one another. Plate boundary zones the zone of the belt where the limits are not very much characterized and the impacts of plate interaction is not clear.

Country around Malaysia is having convergent boundaries also known as a very small collision that which occurred between the lithosphere plates depending on the type involved. Convergence can occur between the ocean and continental plates substantially, or between two plates largely ocean, or between two plates largely continents.

Indonesia is a meeting purpose of a few tectonic plates, situated between two mainland plates: the Eurasian Plate and Australian Plate; and between two maritime plates: the Indian Plate and Pacific Plate. These plates move in connection to each other and much of the time make impacts and are moving 40 – 110 mm consistently as