DECISION MAKING FRAMEWORK FOR AN EARTHQUAKE RESISTANT BUILDING

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Specially for my beloved family,

Thank you for the nurturing and support you have given ...

For the lecturers,

Thank you for all the assistance and the guidance you devoted ...

For my friends,

Thank you for the encouragement and support you have given ...

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ABSTRACT

Earthquake is a natural disaster that is resulted from the abrupt movements on faults or fractures in Earth's lithosphere. The destruction that an earthquake causes depends on its magnitude and duration, or the amount of shaking that occurs. A structure's design and the materials used in its construction also affect the amount of damage the structure incurs. Earthquakes vary from small, imperceptible shaking to large shocks that can be felt over thousands of kilometers. Earthquakes can deform the ground, making buildings and structures collapse. Lives may be lost as a result of destruction. Malaysia is a country with very low seismic activity. However, Malaysia is bordered by Philippines and Indonesia, which are two of the most seismically active countries and certain degree of surface waves could still be felt in our country. Most of the buildings in our country may not consider seismic load during structure design, thus the level of safety remains unknown. Recently, earthquake events have become more frequent. Therefore, engineers have to be alert and kept updated with the knowledge and behavior of earthquake trend in this area. It is vital to assess the precaution measures that can be taken and consider them in the future building design. Therefore, a decision making framework in designing earthquake resistant building especially for school building in Malaysia is needed to help engineers to consider earthquake risk in the building design. This framework employed NERA Program with the assistance of SAP2000 software for analysis of the performance of earthquake resistant building. The proposed framework is then used to verify an actual school project. The verification found that the school building is subjected to additional seismic load during earthquake but the school building structure is still capable of resisting the additional load incurred. This is because the structural capacity for that building is relatively high.

ABSTRAK

Gempa bumi merupakan bencana alam yang dihasilkan dari gerakan pada lithosfer bumi. Gegaran gempa terjadi kerana plat kerak bumi bergerak, di bawah dan jauh daripada satu sama lain. Tahap kerosakan pada struktur bergantung pada tahap gegaran dan tempoh, atau bilangan getaran yang berlaku. Rekabentuk struktur dan bahan yang digunakan dalam pembinaan juga mempengaruhi jumlah kerosakan ke atas struktur. Kesan gempa bumi boleh dirasai walaupun lokasi gempa terletak jauh beribu kilometer. Gempa bumi boleh merosakkan tanah, membuat bangunan dan struktur lain runtuh. Bangunan sekolah mengandungi sejumlah besar pengguna awam pada kebanyakan waktu. Keselamatan pelajar dan guru di sekolah mungkin akan terjejas apabila berlaku gempa bumi. Sebahagian besar bangunan di negara ini tidak direkabentuk untuk menanggung beban gempa bumi dan tahap keselamatan struktur bangunan masih tidak diketahui. Sejak kebelakangan ini, kejadian gempa bumi lebih kerap berlaku. Oleh kerana itu, jurutera perlu berwaspada dan mengambil tahu maklumat mengenai keselamatan bangunan terhadap kejadian gempa bumi. Adalah penting untuk mengambil tindakan pencegahan dan mempertimbangkan rekabentuk struktur yang tahan terhadap gegaran gempa bumi pada bangunan sedia ada dan akan datang. Oleh kerana itu, rangka kerja membuat keputusan dalam merekabentuk bangunan yang dapat menahan daya luar hasil daripada gempa bumi diperlukan. Ia penting terutamanya membantu jurutera untuk mempertimbangkan risiko gempa bumi dalam rekabentuk bangunan sekolah di Malaysia. Rangka ini menggunakan Program NERA dan Program SAP2000 untuk menganalisa prestasi rekabentuk bangunan sedia ada. Pengesahan yang dijalankan ke atas rekabentuk bangunan sekolah sedia ada, mendapati bahawa bangunan sekolah yang dikenakan beban tambahan gempa bumi masih dapat berdiri kukuh. Struktur bangunan sekolah tersebut adalah kukuh dan boleh kekal selamat pada tahap gegaran gempa bumi yang amat tinggi.

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Kg	-	Kilogram
g	-	Gram
N	-	Newton
kN	-	Kilo Newton
kNm	-	Kilo Newton Meter
H	-	Hour
s	-	Second
e	-	Degree of Freedom Vector
m	-	Meter
mm	-	Milimeter
mins	-	Minutes
E	-	Young Modulus
fcu	-	Concrete Compressive Strength
fy	-	Steel Bar Yield Strength
g	-	Gravity Accelaration
M	-	Maximum Moment Capacity
S	-	Maximum Shear Capacity
T	-	Period
u	-	Relative Displacement
UTM	-	Universiti Teknologi Malaysia

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Malaysia is situated on the southern edge of the Eurasian Plate and bordered to the west by the seismically active Indonesia Volcanic Arc (200 – 300km away) which demarcates the inter-plate boundary (subduction zone) between the Indo-Australian and Eurasian Plate and to the east of Sabah by the inter-plate boundary (subduction zone) between the Eurasian and Philippines Plate (Mark Peterson et al., 2007). Although Malaysia is located on the stable Sunda plate, pressure on the continent is mounting Australian, Eurasian and Philippines plates around us to move and push into us. Figure 1.1 shows the shallow-depth earthquakes in the region with epicentres of shallow-focus earthquakes in two categories- the plate boundaries and seismic zone boundary. Seismic in Malaysia is still unknown due to lack of understanding of seismicity and lack of seismic data. Seismic factor in the planning and design of the building structures is not considered in Malaysia.

On 26th December 2004, a large earthquake of 9.0 on the Ritcher scale occurred in west of Acheh in Sumatra, Indonesia. The epicentre was located at latitude 3.1° N and longitude 95.5° E, about 680 kilometres northwest of Kuala Lumpur and 590 kilometres west of Penang. This earthquake had resulted in the generation of a massive and disastrous Indian Ocean-wide tsunami that swept through the coasts of a number of countries region with high “tidal” waves. (Mark Peterson et al., 2007)

Although our country Malaysia was not hit as hard as Acheh, Indonesia, precaution on this incident should be taken because it does not mean that Malaysia could escape from any hazardous events (Adnan et al., 2008). There is thus an urgent need to carry out a study to assess the level of safety for any structure under a seismic load.

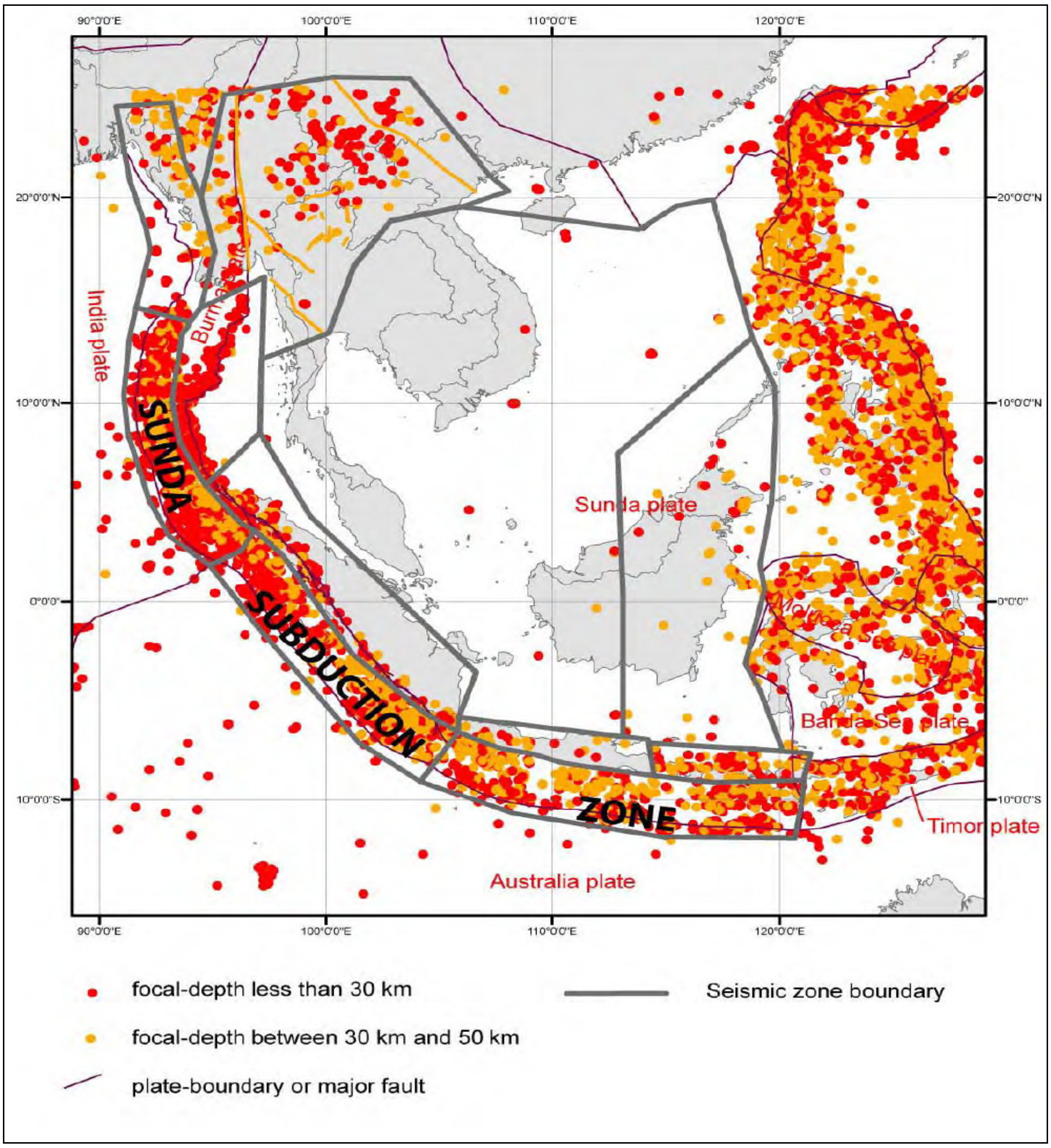

Figure 1.1: Map of Shallow-Depth Earthquakes Location, Plate Boundary and Seismic Zone Boundary (Mark Peterson et al., 2007)

1.2 Problem Statements

Due to the reason that Malaysia is located at a very low potential earthquake zone, most of the buildings in Malaysia are not designed to resist earthquake. This has caused lack of knowledge and attention from design engineer to pay serious detail design in earthquake engineering field. The recent trend shows that earthquake events have become more frequent. Therefore, engineer has to be more alert and updated with the knowledge and behaviour of earthquake trend in this area. In order to evaluate the potential hazard effect on the building's structure due to excessive seismic loading, more research needed to be carry out in this field. Design engineer need to know all the vital information regarding earthquake resistant building. Further question rises on what information need to support the decision of engineer in designing the earthquake resistant building. Are the location of the building highly expose to the earthquake risk? What step of precaution can be taken in analysing existing earthquake loading? Based on the above queries, the following list of the problems form the basis of this research:

a) Which area has the higher risk to be affected by earthquake?
b) What are the potential hazards for building structure affected by excessive seismic loading?
c) Most of the buildings in Malaysia never take seismic design into account, what is the effect of this decision?
d) Malaysia is considered to be an almost seismic-free country. However, it is bordered by Indonesia and Philippines, which are two of the most seismically active countries in this region with frequent earthquakes. Does this mean that Malaysia is free from both distant and local earthquakes risk?
e) What are the consequences of lack of knowledge and attention from the community about earthquake engineering field?
f) What are the precautions that can be taken into consideration for the design parameter of future building design?

1.3 Research Questions

In order to answer the problem statements, engineers have to be equipped with earthquake design information. Therefore the following research questions are important to engineers when designing an earthquake resistant building. A framework to design earthquake resistant building are needed to help engineer to gain information that are required and this framework will also guide engineer to design earthquake resistant building with ease. Beside that, the framework will become a main reference for engineer in understanding earthquake engineering for this region.

1. Maximum acceleration in the building location
2. Method of precaution that could be taken in designing the building's structure.
3. The percentage of loading increment due to seismic activity.
4. The increment of the structural component's size to cater for earthquake loading.
5. The increment of the time and cost of construction in order to design earthquake resistant building.

1.4 Objectives

This research aims to develop a decision making framework that can help engineers in designing earthquake resistant building. In order to achieve the above research aim, the following objectives are established:

1. To identify the required parameter for seismic structural analysis on school building.
2. To propose a decision making framework in designing earthquake resistant building.
3. To validate the framework on the pilot school building project.

1.5 Scope of Work

This research is carried out by using 30 set of boreholes data obtained from Johor Bahru District. All the boreholes selected to conduct this study lie within the area that contains school buildings. All the boreholes data are processed and analysed for school building modelling by using finite element software.

School building is selected to be analyzed because it contains a huge numbers of students and teachers most of the time. Some of the schools which are residential schools have higher impact as it has more students and teachers staying in the building. Significant casualties and property losses could happen due to collapse of these school buildings during strong earthquakes. Furthermore, school buildings might have to be assigned as emergency shelters immediately after any severe earthquake. Therefore, limiting casualties in future earthquake is very important. Hazard and structural performance analysis to those school buildings with high risk potential is one approach towards reducing casualties in future earthquake.

To carry out the research, the pre-field data such as location, area, number of stories, construction types, soil profile and most information related to the school building are collected. Nera Program used to obtain Peak Ground Acceleration (PGA) value from the boreholes data. Collected PGA values are plotted against Johor Bahru district map to produce seismic zone mapping for Johor Bahru District. The seismic zone mapping is useful for earthquake risk management and for future building development consideration.

Modelling and analysis of the building structure characteristic is carried out using SAP 2000 program. SAP 2000 is a very useful tool for earthquake engineering to analyse various type of loading generated from earthquake events. School building structure is modelled in the program and imposed with the earthquake loading from the seismic zone mapping. Additional load generated from the earthquake event is identified and further analysis is carried out to determine the propose earthquake loading to be incorporated in the future building structural design.

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