

INTI

International University & Colleges

LAUREATE INTERNATIONAL UNIVERSITIES

INTI INTERNATIONAL UNIVERSITY

Faculty of Science, Technology, Engineering and Mathematics

FOR REFERENCE ONLY

**Investigation on Earthquake Resistance System Design Based on EC8
for Low Rise Building in Malaysia**

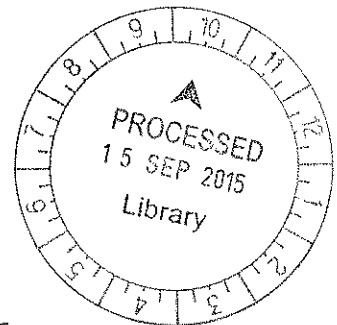
Patrick Rimba

BEng (Hons) in Civil Engineering

Project Supervisor : Ir Siow Yun Tong

Final Year BEng Project

2015



TK
148
PAT
2015

ACKNOWLEDGEMENT

Firstly, I would like to my supervisor and all my mentor to guide me for doing this project and help me a lot for the research project to going smoothly

Secondly , Thanks to my friends that support me and get me some help and idea to do this research project .

Thirdly , I would like to thanks INTI International University for getting a permission for conducting an experiment at Lembaga Getah Malaysia for a result data.

At Last , Thanks to my parents for always support and push me harder to complete this research and always remind me to keep it up my work.

Investigation on Earthquake Resistance System Design Based on EC8 for Low Rise

Building in Malaysia

ABSTRACT

The purpose of this research is to investigate or study the behavior of the earthquake resistance system design based on Euro Code specifically for base isolator and used on low rise building in Malaysia. Recently, the amounts of public infrastructure are continuously be damaged from earthquake problems and by doing this research it may help in engineering field to reduce the damage happened. Base isolator is installing between column and foundation which act as isolator for the earthquake force. The base isolator in this research is going to be tested with compression and shear test to analyze the behavior of the bearing that applied by a certain load. However, a comparison between theoretical and experimental data needs to be done to get a percentage different and compare both compression and shear stiffness behavior of the material. Another comparison of the deflection that need to be done are between finite element analysis using COMSOL Multiphysics 3.5 with lab result. Lastly, using the Euro code 8 to categories the base isolator which is fulfills the criteria that require.

LIST OF TABLE

Table 2.1	Modified Mercalli Intensity Scale
Table 2.2	Correlation with the Mercalli scale
Table 3.1	Properties of Natural Rubber base on Idemat 2003
Table 4.1	Column Load Accumulation
Table 4.2	Design Checking
Table 4.3	Compression Test Result
Table 4.4	Shear Test Result

LIST OF FIGURE

Figure 2.1.1 Earthquake waves spread out

Figure 2.1 Graph of Peak Amplitude versus Distance (Richter 1958)

Figure 2.2 Wood-Anderson short period seismogram

Figure 2.3 Scaled Acceleration histogram based on Chi Chi earthquake 1999 in Taiwan

Figure 2.4 Earthquake Danger Zone based on NOAA National Geophysical Data Center

Figure 2.5 Major tectonic plates around Malaysia

Figure 2.6 Seismicity Map – MOSTI 1900 to March 2012

Figure 2.7 Effect of Earthquake to Residential Building in Izmit 1999

Figure 2.8 Earthquake in Japan 2011

Figure 2.9 Base Isolator

Figure 2.10 Lead Rubber Bearing

Figure 2.11 Sliding Isolation Systems

Figure 2.12 Friction Pendulum System (FPS)

Figure 2.13 Fluid damper

Figure 2.14 Brazilian rubber-tree (*Hevea Brasiliensis*).

Figure 3.1 Rubber Bearing

Figure 3.2 Rubber Bearing Dimension

Figure 3.3 Rubber Bearing Cross-sections

Figure 3.4 Physical Testing Laboratory

Figure 3.5 Compression Test Machine

Figure 3.6 Reverse Cyclic Test Machine

Figure 3.7 Comsol Multiphysics Software

Figure 4.1 Compression Test Load Vs Deflection

Figure 4.2 Shear Test Load Vs Deflection

Figure 4.3 Compression Stiffness Analysis Comsol

Figure 4.4 Shear Stiffness Analysis Comsol

Figure 4.5 Shear Stiffness Analysis Comsol

TABLE OF CONTENT

ACKNOWLEDGEMENT	2
ABSTRACT	3
LIST OF TABLE	4
LIST OF FIGURE	5

Chapter 1: INTRODUCTION

1.1 General Introduction.....	pg10
1.2 Problem Statement.....	pg11
1.3 Objective.....	pg11
1.4 Thesis Organization.....	pg12

Chapter 2: LITERATURE REVIEW

2.1 Introduction	pg13
2.2 Characteristic of Earthquake.....	pg15
2.2.1 Earthquake Magnitude.....	pg15
2.2.1.1 Richter scale.....	pg15
2.2.1.2 Modified Mercalli Intensity Scale.....	pg16
2.2.2 Earthquake Duration.....	pg18
2.2.3 Earthquake Acceleration.....	pg19
2.3 Earthquake Zones in the World.....	pg22
2.4 Earthquake in Malaysia.....	pg23
2.5 Effect of Earthquake.....	pg 25
2.5.1 on Low Rise Buildings.....	pg 25
2.5.2 on High Rise Buildings.....	pg 26
2.6 Earthquake Base Isolator.....	pg 27
2.6.1 Introduction to Base Isolator.....	pg 27

2.6.2 Type of Base isolator.....	pg29
2.6.2.1 Elastomeric Bearings.....	pg29
2.6.2.2 Sliding Isolation Systems.....	pg 30
2.6.2.3 Damping and Energy Dissipation Devices.....	pg 32
2.6.3 Advantages of Earthquake Base isolator.....	pg 24
2.7 Euro Code.....	pg36
2.7.1 Euro Code Background.....	pg36
2.7.2 Euro Code Benefits.....	pg36
2.8 Natural Rubber.....	pg 38
2.8.1 Introduction to Natural Rubber.....	pg38
2.8.2 History of Natural Rubber.....	pg 38
2.8.3 Synthetic Rubber Production System.....	pg 39

Chapter 3: METHODOLOGY

3.1 Material.....	pg 40
3.2 Specimen Preparation.....	pg 41
3.3 Experiment test.....	pg 43
3.3.1 Compression Test.....	pg 44
3.3.2 Reverse Cyclic Load Test.....	pg 45
3.4 Finite Element Analysis.....	pg 46

Chapter 4: RESULT AND DISCUSSION

4.1 Building.....	pg47
4.1.1 Building Design.....	pg47
4.1.2 Building Calculation Result.....	pg49
4.2 Rubber Bearing.....	pg50
4.2.1 Rubber Bearing Design.....	pg50

4.2.2 Rubber Bearing Design Calculation Result.....	pg52
4.2.3 Rubber Bearing Design Lab Test Result.....	pg53
4.3 Finite Element Analysis.....	pg57
4.3.1 Comsol Multiphysics Compression Stiffness Analysis.....	pg57
4.3.2 Comsol Multiphysics Shear Stiffness Analysis.....	pg58
4.4 Discussion.....	pg59
4.4.1 Comparison Between Design and Laboratory Test.....	pg59
4.4.2 Comparison Between Laboratory Test and Finite Element Analysis.....	pg61
4.4.3 Isolation System Base on EC8.....	pg62

Chapter 5: CONCLUSION

5.1 Conclusion.....	pg63
5.2 Recommendation For Future Research	pg64

References	pg65
Appendix A	pg69
Appendix B	pg71
Appendix C	pg76
Ghant Chart	pg82

CHAPTER 1

INTRODUCTION

1.1 General Introduction

An earthquake is created a vibration or seismic waves which result of sudden energy release in the earth crust. Earthquake can be caused by natural fracture of geological fault and other human activity such as mine blasts or nuclear test. It is happened that earthquake can trigger several of natural disasters for example tsunami, landslides, and volcanic activity.

The earthquakes have been studied by many centuries. Today, hundreds of millions people around the world live with serious risk to their property and lives from earthquakes. The amounts of public infrastructure are continuously be damaged from earthquake problems. These problems are not infrequently happened in some countries such as United States, Japan, Indonesia , Taiwan , Hong Kong or any other country. In 2004 an earthquake was occur in Penang island, Malaysia. The tsunami that happened in Aceh, Indonesia generating by the earthquake with the magnitude of 9.0 spread to surrounding area including Penang island with approximately 572.67 km from Banda Aceh. It is reported that 52 persons were death and houses in fishing villages along coastal areas were damaged in the incident.

Earthquake has happened for million years ago and will continually occur throughout the entire world. It is no way to prevent earthquakes from occur, but it is possible to reduce the effect of the seismic to avoid death , injuries and damaged that might be occur.

1.2 Problem Statement

This study purpose meant for investigating on earthquake resistance system that design based on EC8 for low rise building in Malaysia. Earthquake rarely happens in Malaysia but when the earthquake occur, low rise buildings might collapse or badly damage and if it happens in residential area people might be killed and injured with the collapsed building, most the times building fails because the foundation faults cause column to lose their stability to support the load acting on it , causing the whole structure collapse. So, by doing this study about the resistance system design through EC8 it overcomes the collapse or minimize the damage of the low rise building if it struck by an earthquake.

1.3 Objective

- Investigate the behavior of the base isolator due to lateral earthquake forces for low rise building in Malaysia.
- Study the design of the base isolator for taking the vertical earthquake forces that transfer from low rise building in Malaysia.

1.4 Thesis Organization

Chapter 1 is an introduction of the studies which basically is conducting the research, the background of this topic and the objectives is the main outcome for the studies.

Chapter 2 is show the literature review which is scholarly text paper that includes the recent knowledge for both theoretical and methodological contributions to a particular topic and need to be combining together to support the research of the topic.

Chapter 3, methodology is the analysis of the theoretical method in a field of study and the purpose of the research in more detail and structured.

Chapter 4 is the result and analysis of the studies which take a several time for doing the research of the required material such as lab experiment , design , workshop result which are all compile in this chapter.

Chapter 5 the conclusion and recommendation of all the summary of the research that also included references and appendix.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Earthquake is a sudden shaking or essentially vibration of the soil or earth surface move in all directions. The most destruction effects for the building structures especially high rise building that required a good foundation to carry the structure load. In fact that normal building structures are designed for vertical gravity loads where there are no resistant for structures to take the horizontal forces that occur in the earth surface, this will caused structural hazards when the earthquake happen. In 12 May 2008, an earthquake struck China's south-western region with a magnitude of 8.0. It was the strongest earthquake that happen in China since the founding of the People's Republic, not only property loss and causing heavy human casualties but also makes a serious damage to the ecological environment which led to the loss of ecosystem services, ecological safety is threatened and evaluation of the loss of the ecosystem services was vital for post-disaster reconstruction. (Y.KWang, et al. 2012). Earthquake is caused by sudden release of stress in the earth crusts that build a point of weakness and led to large sections of the movement. Earthquake is not happened in every area of the earth surface, perhaps there are certain area that earthquake are frequently occur where it called zone of high probability.

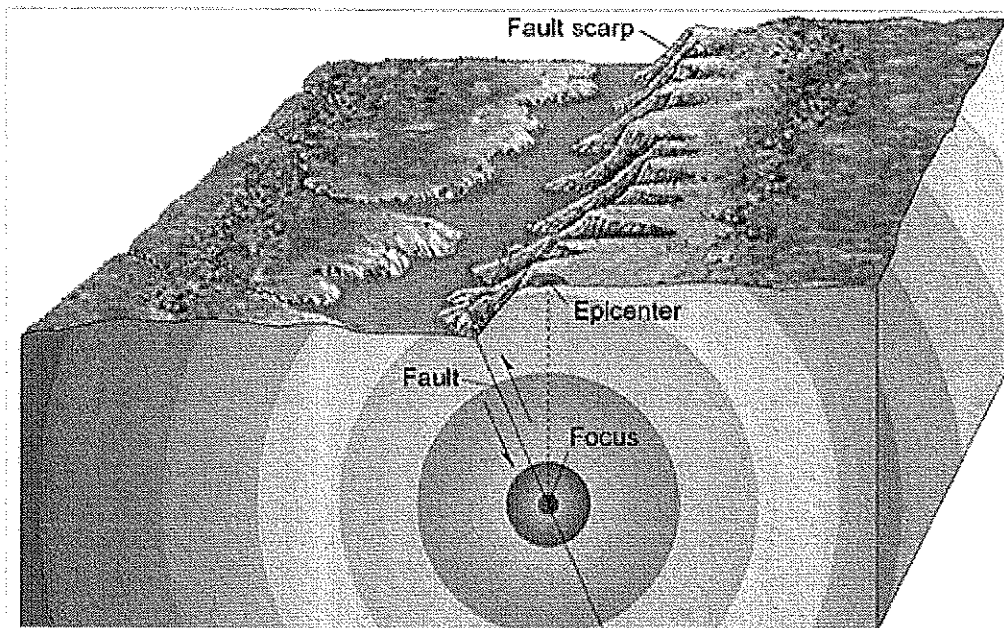


Figure 2.1.1 Earthquake waves spread out

In the figure 2.1.1 shows the Earthquake waves spread out from the inner surface of the earth to the outer surface which can be classified into few points:

- **Focus**- The location where the earthquake begins. The seismic waves spread outward in all directions.
- **Fault**- the surface where when two blocks of the earth suddenly slip past one another.
- **Epicenter**- the location on the surface of the earth directly or perpendicularly above the focus of a earthquakes.

2.2 Characteristic of Earthquake

2.2.1 Earthquake Magnitude

2.2.1.1 Richter scale

In 1935, The Richter Scale was developed by Charles Richter of the California Institute of Technology in Pasadena. He used a Wood-Anderson seismometer to define a magnitude scale of shallow, local earthquakes in southern California. (Richter 1935). Richter constructed a similar diagram as a Japanese seismologist named Kiyoo Wadati in 1931. The diagram shows the peak amplitude versus distance which he used it to create the first earthquake magnitude scale. He based his scale similar for both the stellar brightness scale commonly used in astronomy and also the pH scale that used to measure acidity.

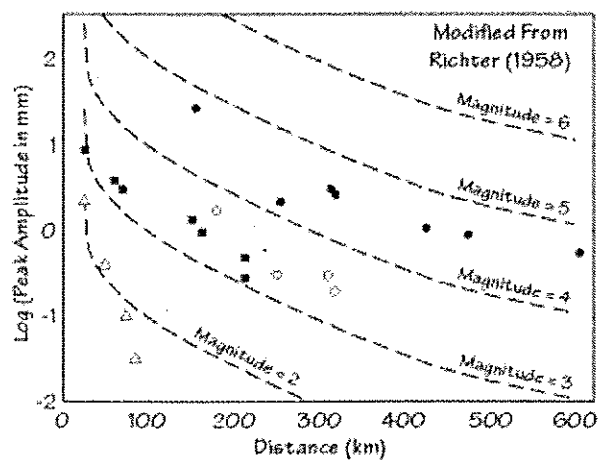


Figure 2.1 Graph of Peak Amplitude versus Distance (Richter 1958)

In a process to complete the construction of the magnitude scale, he identified the rate at which the peak amplitudes will be decrease with distance from an earthquake. Richter was pragmatic in his definition, and chose a value for a magnitude zero that insured that most of the earthquakes