THE EARTHQUAKE EFFECT OF SINGLE STOKEY RC BUILDING STRUCTURE DUE TO SURROUNDING EARTHQUAKE IN MALAYSIA

FATIN NADIAH BINTI KAMARUDIN

Thesis submitted in fulfillment of the requirements for the award of the degree of Bachelor (Hons.) of Civil Engineering

> Faculty of Civil Engineering and Earth Resource UNIVERSITI MALAYSIA PAHANG

> > JUNE 2016

TABLE OF CONTENTS

SUPERVISOR'S DECLARATION	ii
STUDENT'S DECLARATION	iii
ACKNOWLEDGEMENTS	v
ABSTRACT	vi
ABSTRAK	vii
TABLE OF CONTENTS	viii
LIST OF TABLES	xi
LIST OF FIGURES	xiii
LIST OF SYMBOLS	xviii

CHAPTER 1 **INTRODUCTION** . 1.1 Background of Study 1 1.2 Problem Statement/Motivation 3 1.3 Research Objectives 4 1.4 Scope of Study 5 Research Significance 1.5 5

CHAPTER 2 LITERATURE REVIEW

2.1	Introduction	6
2.2	Earthquake	7
2.3	The Earth	12
2.4	Seismic Wave	13
2.5	Measuring Earthquake	19
2.6	Earthquake Magnitude	20
2.7	Concrete Building Structure	22

CHAPTER 3 METHODOLOGY

3.1	Introduction	24
3.2	Literature Review	26
3.3	Gather The Information And Data	27
3.4	ESTEEM Program/Software	28
	3.4.1 Steps in ESTEEM Computer Software	29
3.5	SAP 2000 Program/Software	32
	3.5.1 Steps in ESTEEM Computer Software	33

CHAPTER 4 RESULT AND DISCUSSION

4.1	Introduction	39
4.2	Characteristic of Concrete Single Storey Building	39
4.3	Analysis of Concrete Single Storey Building	39

	4.3.1 Modal Analysis	40
	4.3.2 Dead load + Live Load	45
	4.3.2.1 ESTEEM Software	45
	4.3.2.2 SAP 2000 Software	55
	4.3.3 Dead load + Live load + Earthquake + Wind	61
4.4	Summary of Analysis	67
	4.4.1 Shear Force	67
	4.4.2 Bending Moment	67

CHAPTER 5	CONCLUSION & RECOMMENDATIONS	72
5.1	Conclusion	72
5.2	Recommendations	73
REFERENCES		75

LIST OF TABLES

Table No.	Title	Page
2.1	Frequency of occurrence of earthquakes based on observations since 1900	22
4.1	Result of Dead load and Live load for beam 30 by using ESTEEM 8 Software and SAP 2000 Software	57
4.2	Result of Dead load and Live load for beam 31 by using ESTEEM 8 Software and SAP 2000 Software.	59
4.3	Result of Dead load and Live load for column 1 by using ESTEEM 8 Software and SAP 2000 Software.	61
4.4	Result of Dead load and Live load for beam 30 and result of dead load, live load and earthquake load for beam 30 by using SAP 2000 Software.	63
4.5	Result of Dead load and Live load for beam 31 and result of dead load, live load and earthquake load for beam 31 by using SAP 2000 Software.	65
4.6	Result of Dead load and Live load for column 1 and result of dead load, live load and earthquake load for column 1 by using SAP 2000 Software	67
4.7	Result of shear force between ESTEEM software and SAP 2000 software	68
4.8	Differences of shear force result between different cases of SAP 2000 software	68

4.9	Differences of bending moment result between different software with the same cases	70
4.10	Differences of bending moment between different cases of SAP 2000 software	70

LIST OF FIGURES

Figure No.	Title	Page
1.1	Convection current into the Earth	2
1.2	Screen capped from Earthquake Track website	4
2.1	Earthquake waves spread out	8
2.2	Crustal Stress	9
2.3	Location of earth surface	10
2.4	Types of fault	10
2.5	Earthquakes which happened at 2000 until 2006	11
2.6	The structure of the earth	13
2.7	Simplified represent of building behavior during an earthquake	14
2.8	P-waves and S-waves	17
2.9	Rayleigh waves and Love waves	18
2.10	Difference of waves	18
2.11	How seismograph moving	19
2.12	Differences of the wave using seismogram	20
3.1	Flowchart of the study	25

3.2	Some of the books which being used for the research	26
3.3	Drawing of single storey of concrete with dimension	28
3.4	ESTEEM sofware	28
3.5	Building which design with ESTEEM software	29
3.6	Parameter of ESTEEM software	29
3.7	Gridline of ESTEEM software	30
3.8	Structure Layout in ESTEEM software (3D)	31
3.9	Batch Analysis and Design and Deign Results	31
3.10	Project integrity and plan integrity	32
3.11	Building which design with SAP 2000 software	33
3.12	Select structure model type	34
3.13	Define grid system data	34
3.14	Add restraints at the base condition	35
3.15	Structure Layout in SAP 2000 (3D)	36
3.16	Load combination data	37
3.17	Time History	38
4.1	Mode shape 1 with period of 0.221606 and Mode shape 2 with period of 0.215513	41
4.2	Mode shape 3 with period of 0.209459 and Mode shape 4 with period of 0.204549	41

4.3	Mode shape 5 with period of 0.201014 and Mode shape 6 with period of 0.199999	42
4.4	Mode shape 7 with period of 0.196741 and Mode shape 8 with period of 0.196741	42
4.5	Mode shape 9 with period of 0.187283 and Mode shape 10 with period of 0.185838	43
4.6	Mode shape 11 with period of 0.18129 and Mode shape 12 with period of 0.179255	43
4.7	Modal period and frequencies	44
4.8	Beam 30	45
4.9	Result of moment from the ESTEEM 8 software for beam 30	46
4.10	Result of shear force from the ESTEEM 8 software for beam 30	46
4.11	Result of torsion from the ESTEEM 8 software for beam 30	46
4.12	Result of deflection from the ESTEEM 8 software for beam 30	47
4.13	Result of moment from the ESTEEM 8 software for beam 31	49
4.14	Result of shear force from the ESTEEM 8 software for beam 31	49
4.15	Result of torsion from the ESTEEM 8 software for beam 31	50
4.16	Result of deflection from the ESTEEM 8 software for beam 31	50
4.17	Result of the maximum moment at y direction and maximum shear force at z direction from the ESTEEM 8 software for	52

column 1

4.18	Result of the maximum moment at z direction and maximum shear force at y direction from the ESTEEM 8 software for column 1	53
4.19	Result of the maximum moment and maximum shear force from the SAP 2000 software for beam 30	55
4.20	Result of the axial force and torsion from the SAP 2000 software for beam 30	56
4.21	Result of the deflection and stress from the SAP 2000 software for beam 30	56
4.22	Result of the maximum moment and maximum shear force from the SAP 2000 software for beam 31	57
4.23	Result of the axial force and torsion from the SAP 2000 software for beam 31	58
4.24	Result of the deflection and stress from the SAP 2000 software for beam 31	58
4.25	Result of the maximum moment and maximum shear force from the SAP 2000 software for column 1	59
4.26	Result of the axial force and torsion from the SAP 2000 software for column 1	60
4.27	Result of the deflection and stress, from the SAP 2000 software for column 1	60
4.28	Result of the maximum moment and maximum shear force from the SAP 2000 software for beam 30	62

4.29	Result of the axial force and torsion from the SAP 2000 software for beam 30	62
4.30	Result of stress from the SAP 2000 software for beam 30	62
4.31	Result of the maximum moment and maximum shear force from the SAP 2000 software for beam 31	64
4.32	Result of the axial force and torsion from the SAP 2000 software for beam 31	64
4.33	Result of stress from the SAP 2000 software for beam 31	64
4.34	Result of the maximum moment and maximum shear force from the SAP 2000 software for column 1	66
4.35	Result of the axial force and torsion from the SAP 2000 software for column 1	66
4.36	Result of stress from the SAP 2000 software for column 1	66
5.1	Maps of where the earthquake started near the Malaysia latest	74

LIST OF SYMBLOS

%	Percentage
km/sec	Kilometer per second
MPA	Mega Pascal
/sec	Per second
sec	Second
kN	Kilo Newton
kNm	Kilo Newton meter
mm	Millimeter
mm²	Millimeter square
Т	Torsion
V	Shear
b	Section Width
d	Effective depth
Α	Area
u	Beam perimeter

t	Thickness of box section
Ak	Area within centerline
uk	Perimeter of centerline
Z	Inner Lever Arm
VSS	Shear Stress due to Loading,
N/mm²	Newton per millimeter square
V	Strength Reduction Factor for Torsion and Shear
Fck	Strength classes of concrete
fcd	Concrete stress-strain
θ	Angle
TRd,max	Maximum Torsion Moment Resistance
kNm/m	Kilo Newton meter per meter
VRd,max	Maximum Shear Resistance
TEd	Torsion force
VEd	Shear force
vRd,max	Maximum Shear Stress Allowed

LIST OF ABBREVIATIONS

- RC Reinforced Concrete
- EC2 EuroCode 2
- 3D Three Dimension
- 2D Two Dimension
- R Rebar
- C Concrete

THE EARTHQUAKE EFFECT OF SINGLE STOKEY RC BUILDING STRUCTURE DUE TO SURROUNDING EARTHQUAKE IN MALAYSIA

FATIN NADIAH BINTI KAMARUDIN

Thesis submitted in fulfillment of the requirements for the award of the degree of Bachelor (Hons.) of Civil Engineering

> Faculty of Civil Engineering and Earth Resource UNIVERSITI MALAYSIA PAHANG

> > JUNE 2016

ABSTRACT

Nowadays, earthquake had happened in Malaysia. So, a study of earthquake was carrying out for Malaysia which is for single storey concrete building. For this study, there are two software being used to get data of effect of single storey building due to surrounding earthquake and not surrounding earthquake which are ESTEEM software and SAP 2000 software. ESTEEM software and SAP 2000 software have differences step to use it and advantage of using the software to the engineer or users. ESTEEM software and SAP 2000 software produce differences of result and this research is carry out to know why there are difference between this two software. By using SAP 2000, the best mode shape of three vibration analysis can be determined. ESTEEM software and SAP 2000 software. SAP 2000 using Acheh's data of earthquake but for ESTEEM software insert for angle of earthquake or waves which will come to the building.

ABSTRAK

Pada masa kini, gempa bumi yang berlaku di Malaysia. Jadi, satu kajian gempa bumi dijalankan untuk Malaysia iaitu bangunan konkrit satu tingkat telah dipilih. Untuk kajian ini, terdapat dua perisian yang digunakan untuk mendapatkan data kesan kepada bangunan satu tingkat yang berada di sekitar gempa bumi dan tidak berada di sekitar gempa bumi iaitu perisian ESTEEM dan perisian SAP 2000. Perisian ESTEEM dan perisian SAP 2000 mempunyai perbezaan cara-cara untuk menggunakannya dan kelebihan menggunakan perisian tersebut kepada jurutera atau pengguna. Perisian ESTEEM dan SAP 2000 mempunyai perbezaan di antara perisian ini dua. Ini adalah untuk menentukan analisis perbandingan menggunakan perisian ESTEEM dan perisian SAP 2000. Dengan menggunakan SAP 2000, bentuk mod terbaik daripada tiga analisis getaran boleh ditentukan. perisian ESTEEM dan perisian SAP 2000 boleh memasukkan data gempa bumi tetapi masih terdapat perbezaan pada setiap perisian. SAP 2000 menggunakan data Acheh gempa bumi tetapi untuk memasukkan perisian ESTEEM untuk sudut gempa bumi atau gelombang yang akan datang kepada bangunan.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

In Malaysia, mostly 90% of the building that made up is designed without considering of the earthquake effects. Earthquake can occurs everywhere throughout the world at any time. Nowadays, earthquake happened in Malaysia, for example of earthquake in Malaysia at Tasik Kenyir, Terengganu (2010), Bukit Tinggi, Pahang (2007), Lahad Datu, Sabah (2012) and Ranau, Sabah (2015). Earthquakes can cause devastating effects in terms of loss of life and livelihood (Amr S. Elnashai, Luigi Di Sarno, 2008). Just only a few minutes, homes, goods and relatives can be lost. Extensive structural damage is suffered by buildings, bridges, highways and other lifelines during earthquakes. So that building must be design with considering of the earthquake effects.

For the last 39 years ago, Malaysia having earthquake reported at Lahad Datu which is in 1976 and the earthquake measuring is 5.8 on Richter scale which is the strongest earthquake record. This is causing heavy damage to the property and crack to the building. Supposed to the engineer should have acted earlier which is designed the building with considering the earthquake effects. But engineer still design the building without considering the earthquake effects. The latest one at Ranau,Sabah, has earthquake measuring at 5.9 magnitude which is the strongest earthquake hit Malaysia. The effect of this earthquake are damaged of road and building which are a hospital and schools on Sabah's west coast. Moreover, the twin rock formation on the mountain known as the "Donkey's Ears" are broke (Eileen Ng Associated Press,2015). Now engineer need to learn on with design the building with considering earthquake effects.

The possibility Malaysia of being hit by a strong earthquake remains slim. As Dr Mohd Rosaidi Che Abas,54, a seismology expert who has a Doctorate in earthquake studies at Universiti Teknologi Malaysia and a Master degree in seismology from Jaoan's International of Seismology and Earthquake Engineering, who has been with the meteorological department for the last 30 years, said that the threat of an earthquake in Malaysia cannot be ignored. Malaysia very close area which have experienced with the strong earthquakes along with Sumatra and the Andaman Sea, meanwhile Sarawak and Sabah are placed close to the earthquake zone of South Philippines and North Sulawesi. Thus, the chance of an earthquake remarkable cannot be taboo. (said Dr Mohd Rosaidi Che Abas to Bernama at the Meteorological Department's headquarters).

Inside of the Earth is where the seismic movements are developed. The movements are developed by the convection currents produced in the viscous mantle hence to the prevailing high pressure and high temperature gradient between the core and the crust. This convection currents result in an Earth circulation masses, the hot molten lava come out and the cold rock mass goes down into the Earth.



Figure 1.1: Convection current into the Earth (Source: USGS,nd)

Short-term and long-term effects should be known in quantify social and economic consequences. The built environment will be damage because of the earthquake effect and additionally to straightforward shaking effects, earthquakes may direct to various forms of ground failure which produce damage to the built environment.

1.2 PROBLEM STATEMENT/MOTIVATON

Earthquakes are commonly caused when rock underground unexpectedly breaks along with defect. This unexpectedly liberate of energy generates the seismic waves that make the ground shake. Ground shaking is by far the most important hazard resulting from earthquakes, with some exceptions. The Asian tsunami of 26 December 2004 with about 280,000 people killed (Amr S. Elnashai, Luigi Di Sarno, 2008). On 5 June 2015 a moderate 5.9 magnitude shake hit Ranau and killing 18 people.

Earthquakes are the effect of more than 1.5 million deaths worldwide during the 20th Century. Earthquakes do not kill people but the building collapse because of earthquake effect can kill people. It is unbelievable situation which is, after a century of research works, each earthquake brings new surprises and creates the situation that new lessons have to be learned (Luis Esteva, 2005).

From the Earthquake Track, northernmost tip of Sabah have mostly 13 earthquakes which between 4.0 until 6.0 magnitude. So structural building must be design with considering earthquake effect so at least the building will be not damaged due to the earthquake.

REFERENCES

Amr S. Elnashai and Luigi Di Sarno.(2008). Fundamentals of Earthquake Engineering.

Eileen Ng (Associated Press). The Star. (06 Jun 2015). <u>http://www.thestar.com/news</u> /world/2015/06/06/death-toll-rises-to-13-after-quake-hits-malaysias-highestpeak.html

- Victor Gioncu and Federico M. Mazzolani. (2011). Earthquake engineering for structural design. Preface, first published by Spon Press.
- International Code Council, Inc., S. K. Ghosh and David A. Fanella. (2003) Seismic and Wind Design of Concrete Buildings. 2000 IBS ASCE 7-98 ACI 318-99.
- Petros Komodromos and Witpress. (2000). Advances in Earthquake Engineering, Seismic Isolation For Earthquake Resistant Structures.

Denton A. P. The British Geological Survey. <u>http://www.bgs.ac.uk/discovering</u> <u>Geology/hazards/earthquakes/whatIs.html</u>

Kaye M. Shedlock & Louis C. Pakiser. (1995). <u>http://pubs.usgs.gov/gip/earthq1/where.</u> <u>html</u> Professor Larry Braile. seismology, geophysics, earth science education. (2000). http://web.ics.purdue.edu/~braile/edumod/waves/WaveDemo.htm

Shedlock K. M. & Pakiser L. C. (1995). http://pubs.usgs.gov/gip/earthq1/index.html

Thomas Paulay and M. J. N. Priestley. (March 1992). Seismic Design of Reinforced Concrete and Masonry Buildings..

Steven L. Kramer. (Jan 1996) Geotechnical Earthquake Engineering.

- Finley A. Charney. (10. March 2015). Seismic Loads: Guide to the Seismic Load Provisions of ASCE 7-10.
- Andrew King. (2013). Structural Engineering Section Leader Building Research Association of New Zealand (BRANZ). Earthquake Loads & Earthquake Resistant Design of Buildings.

Datta T. (2010). Seismic analysis of structures. Singapore: John Wiley & Sons Asia.

Ghobarah, A. (2001). Performance-Based Design in Earthquake Engineering : State of Development, Engineering Structures.