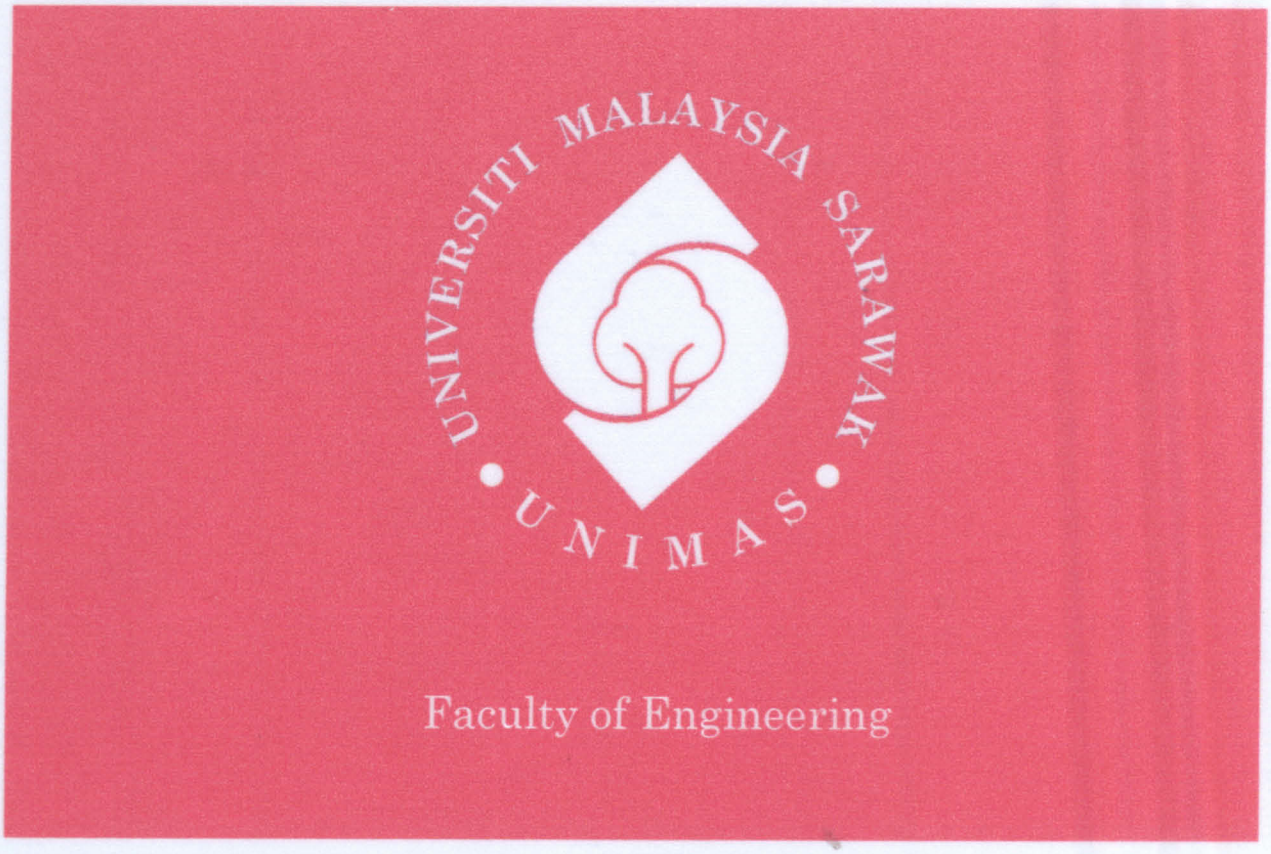

THE INFLUENCE OF STRENGTH ECCENTRICITY IN DISPLACEMENT OF ONE STOREY REINFORCED CONCRETE BUILDING DUE TO SEQUENTIAL EARTHQUAKE

Nurull Farah Dillah Mohd Kashim

Bachelor of Engineering (Hons)

Civil Engineering

2018/2019

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report	√
Masters	
PhD	

DECLARATION OF ORIGINAL WORK

This declaration is made on 12th June 2019.

Students' Declaration:

I, Nurull Farah Dillah Mohd Kashim with matric number of 50886 from Faculty of Engineering hereby declare that the work entitled, The Influence of Strength Eccentricity in Displacement of One Storey Reinforced Concrete Building due to Sequential Earthquake is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

12th June 2019 — Nurull Farah Dillah Mohd Kashim (50886)

Date submitted — STUDENT'S NAME (MATRIC NO.)

Supervisor's Declaration:

I, Azida Haji Rashidi hereby certifies that the work entitled, The Influence of Strength Eccentricity in Displacement of One Storey Reinforced Concrete Building due to Sequential Earthquake prepared by the above named student, and was submitted to the "FACULTY" as a partial KNS 4254 Final Year Project fulfilment for the conferment of Bachelor Of Engineering With Honours (Civil Engineering), and the aforementioned work, to the best of my knowledge, is the said students' work

Received for examination by:

(Azida Haji Rashidi)

Date: 12th June 2019

I declare this Project/Thesis is classified as (Please tick (√)):

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*

☐ **RESTRICTED** (Contains restricted information as specified by the organisation where research was done) *

☑ **OPEN ACCESS**

Validation of Project/Thesis

I therefore duly affirmed with free consent and willingness declared that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abide interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies for the purpose of academic and research only and not for other purpose.
- The Centre for Academic Information Services has the lawful right to digitise the content to for the Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic exchange between Higher Learning Institute.
- No dispute or any claim shall arise from the student itself neither third party on this Project/Thesis once it becomes sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student except with UNIMAS permission.

Student's signature: _____ (12th June 2019)

Supervisor's signature: _____ (12th June 2019)

Current Address:
Dept. Of Civil Engineering, Faculty Of Engineering, 94300 Kota Samarahan, Sarawak

Notes: * If the Report is **CONFIDENTIAL** or **RESTRICTED**, please attach together as annexure a letter from the organisation with the period and reasons of confidentiality and restriction.

THE INFLUENCE OF STRENGTH ECCENTRICITY IN DISPLACEMENT OF ONE STOREY REINFORCED CONCRETE BUILDING DUE TO SEQUENTIAL EARTHQUAKE

NURULL FARAH DILLAH MOHD KASHIM

A dissertation submitted in partial fulfilment of the requirement for the degree of Bachelor of Engineering with Honours

Civil Engineering

Faculty of Engineering

Universiti Malaysia Sarawak

2018

To me, myself and I

ACKNOWLEDGEMENT

I would like to express my highest gratitude to Allah the Almighty for giving the chances, strength and the knowledge to conduct this study. I also would like to express my appreciation to my one and only supervisor, Madam Azida binti Haji Rashidi from Civil Engineering Department, Universiti Malaysia Sarawak for the generous assistance and guidance on this study. I'm sincerely grateful for her to share the knowledge, useful critiques, numerous consultations and friendly advice during the study is still ongoing.

I would like to shower my special gratitude towards my parents and my family for their trust, time and love that help me in finishing this study when I'm on the verge of breaking down. Giving this opportunity, I would also like to convey my indebtedness to my best friend, Ein Amanda Aminuddin for her willingness to stay by my side all this time. Finally, I would like to expand my deepest gratitude to all those who have either directly or indirectly helped me in completing this study.

ABSTRACT

The torsional response causes the displacement of the shear wall of a building. In this study, five stiffness eccentricity are varied with respect to nine constant strength eccentricity which are made as the parameters. An asymmetric reinforced concrete building then is used as the model structure. Seven-pair of earthquake of single earthquake (GM1) are then applied onto the structure using RUAUMOKO-3D that produced displacement at the stiff shear wall and flexible shear wall of the model. The method is then repeated by applying seven-pairs of earth sequential earthquake (GM2). The centre of stiffness, CS, centre of strength, CV and centre of mass, CM are collected from RUAUMOKO-3D. The data then are extracted by using Microsoft Excel. The displacement of CV and CS are average to the displacement of CM to get normalised displacement. It is found that when CSs are further from CM the displacement are insignificant compared to when CVs are further from CM. Another outcome shows that the flexible shear wall has higher displacement than the stiff shear wall. Finally, the results for GM2 have higher displacement than GM1.

ABSTRAK

Tindak balas putaran menyebabkan sesaran terhadap dinding ricih sesuatu bangunan. Untuk kajian ini lima,sifat esentrik kekentalan berubah mengikut sembilan sifat esentrik kekuatan telah dijadikan sebagai parameter. Struktur model bangunan konkrit dibina berdasarkan bangunan konkrit tetulang simetrik telah dijadikan sebagai model. 7 pasangan germpa bumi daripada satu gempa bumi (GM1) diterapkan ke atas struktur menggunakan RUAUMOKO-3D yang dihasilkan sesaran oleh dinding ricih keras dan dinding ricih fleksibel. Kaedah ini diulang semula ke atas struktur dengan gempa bumi berulang (GM2). Pusat kekentalan bangunan, CS, pusat kekuatan bangunan, CV dan pusat jisim bangunan, CM adalah data yang boleh didapati daripada RUAUMOKO-3D. Data tersebut akan diekstrak menggunakan Microsoft Excel. CV dan CS akan dibahagikan dengan CM untuk mendapatkan graf sesaran yang telah dinormalisasi. Daripada kajian didapati apabila CS jauh daripada CM nilai sesaran tidak menunjukkan impak yang tinggi seperti apabila CV jauh daripada CM. Selain itu, data terkumpul juga menunjukkan, sesaran dinding ricih fleksibel lebih tinggi daripada dinding ricih keras. Akhir sekali, GM2 menunjukkan bacaan sesaran yang lebih tinggi daripada GM1.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLE

LIST OF ABBREVIATION

M_W	-	Magnitude underwater
M_s	-	Magnitude on surface
CM	-	Centre of mass
CV	-	Centre of strength
CS	-	Centre of stiffness
UBC	-	Uniform Building Code
EC	-	Eurocode
NZC	-	New Zealand Code
NBCC	-	National Building Code of Canada
T	-	The Period of Vibration
q	-	The behaviour factor
r	-	The slope
e_s	-	The stiffness eccentricity (distance)
e_v	-	The strength eccentricity (distance)
FI	-	Far-inelastic displacement
FE	-	Far-elastic displacement
NI	-	Near-inelastic displacement
NE	-	Near-elastic Displacement
GM1	-	Ground motion 1
GM2	-	Ground motion 2

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter demonstrates an overview of the effect of destruction on the reinforced concrete building due to the sequential earthquake. Objectives and scope of studies are discussed in this chapter.

1.2 Background

According to the Oxford dictionary, seismic is known as earthquakes or other vibrations of the earth and its crust. Earthquakes are classified as one of a natural catastrophe as it is caused by natural phenomena of the earth. It is classified as one of natural catastrophe because it causes losses of life, decreasing the economic value of a country and damage to the infrastructure of a country where it will take several months or years to recover back from the catastrophe. The vibration, displacement and shaking of ground cause earthquakes as it is produced by the movement of the ground. An earthquake happened at the epicentre as it is directly above the earth hypocentre or focus where the earthquake originates. Hypocentre is where the origin of the earthquake happened and it is the initial point where the faults begin to rupture.

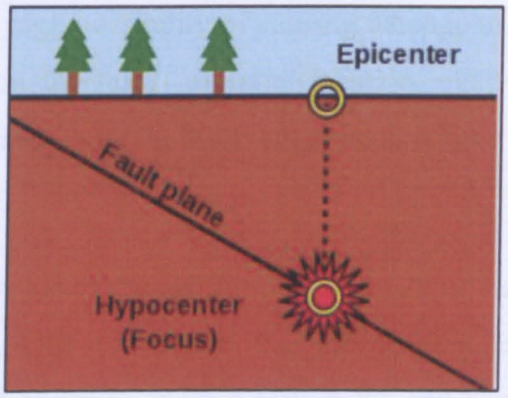

Figure 1.1: Hypocentre and Epicentre (Wikipedia, 2018)

Sequential earthquakes are rare occasions that will happen during a natural catastrophe, all the regions that are near to a fault in the world took some precaution as it is an unpredictable occasion. According to Abdelnaby (2012), a series of earthquakes can be categorised as fore-, main- and after-shocks or known as sequence of independent earthquakes from proximate fault segments but it is hard to identify as it is hard to be detected. A series of earthquakes happened due to the first earthquake that accumulates strains that cause high stress at a different location and thus to release the strain and stress and to completely stabilized the faults systems, sequential ruptures happened and causes the multiple earthquakes. A structure that is built using reinforced concrete is prone to be vulnerable to sequential earthquakes. Aftershocks are also known as a smaller earthquake that happened after the main shock. An aftershock mostly happened near to the fault rupture or any other faults within the main shock as it is being affected by the strain and stress of the first rupture. Abdelnaby (2012) said that if an aftershock happens to be higher than the main shock, the original main shock will be classified as a foreshock.

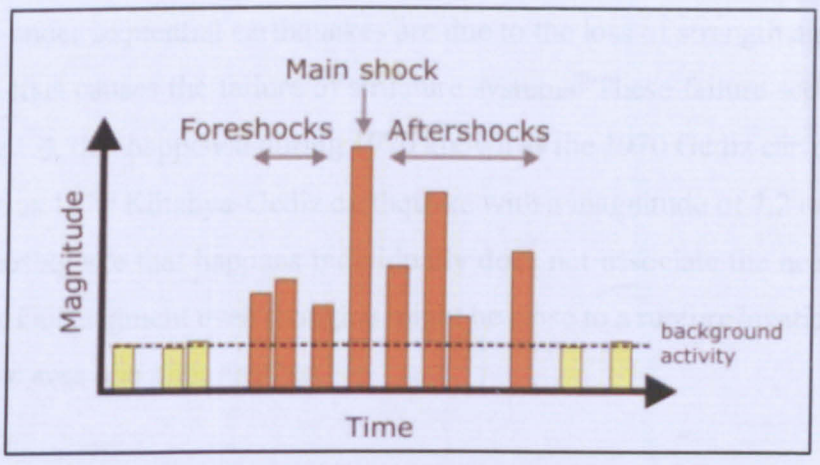

Figure 1.2: Illustration of an Earthquake Sequence (Abdelnaby, 2012)

Aftershock has a high possibility of causing damage to a building structure as it is cannot be predicted in the terms of time, location and what does triggering the aftershock and it will damage more the lower structure as it has a small amount of stiffness and strength capacities.

Independent earthquakes are not formed by a nearer earthquake as the strain of the nearest earthquake does not cause the independent earthquake. Independent earthquake might happen nearer to another earthquake and happen to hit the same area within the seismic zone. Figure 1.3, is an example of an independent earthquake that can be seen from the 1999 Turkey Earthquake, Izmit earthquakes occur on 17 August with 7.4 M_W while Duzce earthquake happened on 12 November with 7.2 M_W. Even though the Duzce Earthquake happened at the same area as Izmit Earthquake, Duzce Earthquake does not affected by the strain from Izmit Earthquake and it cannot be classified as sequential earth as the epicentre of each earthquake is at a different location.

Figure 1.3: 1999 Earthquake at Izmit and Duzce (Bohnhoff et al., 2013)

During these few years, few researchers have done research about the collapsing of building under sequential earthquake. Most of the research concludes that the collapsed of a building under sequential earthquakes are due to the loss of strength and stiffness of the buildings thus causes the failure of structure systems. These failure scenarios can be seen in figure 1.4, that happened during 1970 known as the 1970 Gediz earthquake which is also known as 1970 Kütahya-Gediz earthquake with a magnitude of 7.2 on M_s in scale. A series of earthquake that happens individually does not associate the nearest strain of the proximate fault segment even though it might be close to a rupture location they might strike the same area one after another.

Figure 1.4: 1970 Gediz Earthquake; (a) Left; After the Main Shock (b) Right; the Aftershock

As discussed above, the collapsing of a building structure are the outturn due to sequential earthquakes. According to Abdelnaby (2012), the current building code such as ISO 3010, Eurocode 8 and Uniform Building Code do not really consider sequential earthquake effects in design and assessment because of the difficulty on developing and administering a model.

In designing a building under seismic area, there are few factors that need to be considered. The first factor is torsion, where it is the major cause of a collapsing of a building. Uneven mass distribution at the centre of the mass CM can cause "torsion" that will generate stress concentration. A building generally will damp out any vibrations by absorbing the vibration. The ductility of a building is important when designing a building in a seismic area as it considers the nature of the material used in a building a good design and quality material affect the deformation of a building. Building configuration also important as they determine where the forces of seismic distributed. Last but not least is the strength and stiffness of the building. Strength in this study is the strength of a structure which is mainly focussing on carrying load bear and resist when forces are exerted on it without any failure in shear, elongation or yield (Lorant, 2016).

1.3 Problem Statement

Based on the past research, the current building code such as ISO 3010, Eurocode 8 and Uniform Building Code do not really consider sequential earthquake effects in design and assessment because of the difficulty on developing and administering a model. It is said that sequential earthquake brings more damages than a single earthquake. The building code also more focusing on elastic displacement as building is design to be elastic torsional and not inelastic as they believe that strength eccentricity and stiffness eccentricity work independently and not interrelated to each other.

The model that is being used in by the past research using the same stiffness in some simplified model and the variation of stiffness eccentricity with respect to the position of the centre of mass and strength eccentricity has not yet discussed. Extensive research regarding torsion of a building can be seen more than displacement. Also based on the past research, a point is picked and the value of the point is assumed with increasing the value to the nearest round numbers.

Therefore this study will use a 3D-model based on the Mohamed Noor (2016) and Rashidi and etc. (2017) that have been modified the value with seven (7) consecutive earthquake for all of the ground motion. The study will also more focusing on displacement instead of torsion.

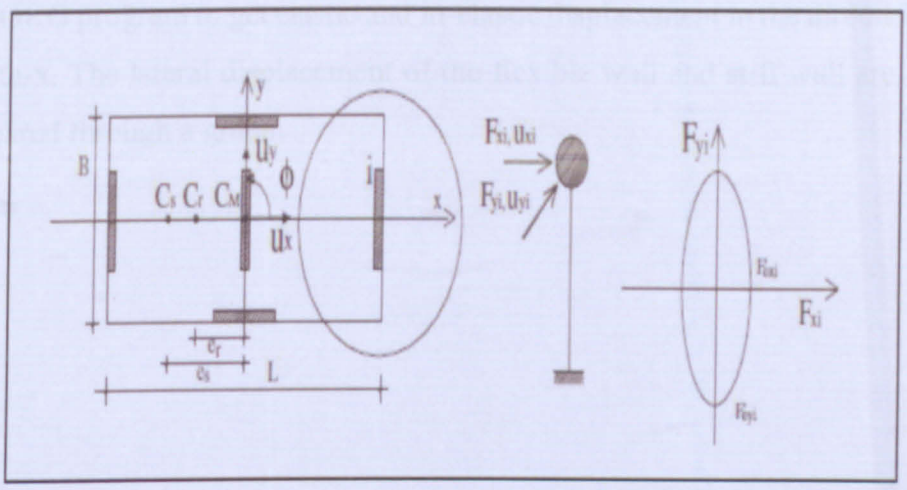

Figure 1.5: Past Research; One-storey Asymmetric Building Simplified Model (De Stefano and Pintucchi, 2008)

1.4 Objectives

The objective of these studies is as below:-

1. To determine the elastic and inelastic displacement with varying the stiffness eccentricity to a constant strength eccentricity of one-storey reinforced concrete building when sequential earthquakes are applied to the structure.
2. Investigate the effect of sequential earthquake on one storey building by varying the centre of stiffness to a constant centre of strength.

1.5 Scope of Study

This study is a further study from Mohamed Noor (2016) and Rashidi, Majid, Fadzli, Faisal, and Noor, (2017) thesis and the building generic building model adopted from De Stefano and Pintucchi (2008). One storey of an asymmetric reinforced concrete building was constructed using RUAUMOKO-3D program in order to get the displacement of the shear wall in z-direction and x-direction. The modelled building was designed with a centre of mass CM, a centre of strength CV and centre of stiffness CS. The value of the strength eccentricity is varying between each lapse of earthquakes. 7 pairs of near-fault and far-fault ground motions were tested and recorded using the RUAUMOKO program to get elastic and in-elastic displacement in the direction of delta-z and theta-x. The lateral displacement of the flexible wall and stiff wall are calculated and compared through a graph.

1.6 Thesis Layout

Below is the explanation of the thesis structure.

Chapter 1 discuss the background, project problem statement, objectives that need to be achieved, the scope of studies and the thesis layout.

Chapter 2 study and review the past research on ground motion, seismic responses of building towards earthquake, irregular structure, strength eccentricity and the elastic and inelastic displacement.

Chapter 3 presents the adopted structure model, modified structure model, ways of collecting data using RUAUMOKO-3D and ways of analysing data to achieve the objective.

Chapter 4 is showing the graphical analysis that can be made from the normalised displacement graph. 80 graph is being discussed in that chapter.

Chapter 5 is the conclusion that can be made from the discussion that has been discussing in chapter 4 and recommendation for future study are proposed in the chapter. And the check whether the objectives are achieved or not.