SEISMIC ANALYSIS OF KOLEJ KEDIAMAN TUN MUSTAPHA UMS AND STAFF QUARTERS SMK DESA WAWASAN TAMBUNAN

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ABSTRACT

An earthquake is a rapid movement of geological components under the earth's surface that causes tectonic plate boundaries to shake violently. Various damages have happened due to the earthquake, which has led to a devastating impact on humans in terms of finances, safety, and health. Nowadays, most existing buildings are designed under British Standards, and the earthquake element is not taken into account. This issue should be addressed because if the building collapsed, many lives would be lost, especially in buildings with a large number of occupants. Therefore, this research aimed to investigate the performance level of Kolej Kediaman Tun Mustapha and Staff quarters SMK Desa Wawasan using a simulation of various PGA values, which include 0.145g, 0.097g, and 0.048g. There were two (2) objectives that needed to be achieved in this study: (1) to examine the structural deformation of the buildings by using computer software, which is PROTA STRUCTURE, and (2) to determine the safety status of the building based on the standard FEMA 356 (2000). Based on the lateral displacement generated from the software analysis, the value of displacements for both buildings on the x and y-axis increased with storey height increases. Meanwhile, based on the interstorey drift ratio (IDR) values for both buildings, it can be concluded that all the buildings were categorized as Immediate Occupancy (IO) under the standard of FEMA 356 (2000).

ABSTRAK

ANALISIS SEISMIK KOLEJ KEDIAMAN TUN MUSTAPHA DAN KUARTERS KAKITANGAN SMK DESA WAWASAN TAMBUNAN

Gempa bumi ialah pergerakan pantas komponen geologi di bawah permukaan bumi yang menyebabkan sempadan plat tektonik bergegar dengan kuat. Pelbagai kerosakan telah berlaku akibat gempa bumi yang telah memberi kesan buruk kepada manusia dari segi kewangan, keselamatan dan kesihatan. Pada masa kini, majoriti bangunan sedia ada direka mengikut Piawaian British, dan elemen seismik tidak diambil kira. Isu ini harus ditangani kerana bangunan runtuh akibat gempa bumi, banyak nyawa akan terkorban terutama di bangunan yang mempunyai bilangan penghuni yang ramai. Hasilnya, kertas kerja ini bertujuan untuk menyiasat tahap prestasi Kolej Kediaman Tun Mustapha dan kuarters Kakitangan SMK Desa Wawasan menggunakan simulasi pelbagai nilai PGA iaitu 0.145g, 0.097g, dan 0.048g. Terdapat dua (2) objektif yang perlu dicapai dalam kajian ini iaitu (1) untuk meneliti ubah bentuk struktur bangunan dengan menggunakan perisian komputer, iaitu PROTA STRUCTURE, dan (2) untuk menentukan status keselamatan bangunan berdasarkan piawaian FEMA 356 (2000). Berdasarkan anjakan sisi yang dijana daripada analisis perisian, nilai anjakan bagi kedua-dua bangunan pada paksi-x dan y meningkat dengan peningkatan ketinggian tingkat. Manakala berdasarkan nilai nisbah perubahan antara tingkat (IDR) bagi kedua-dua bangunan tersebut, dapat disimpulkan bahawa kesemua bangunan tersebut dikategorikan sebagai 'Immediate Occupancy' (IO) di bawah piawaian FEMA 356 (2000).

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Δ_i - Displacement of the adjacent storey.

h_i - Height of storey.

LIST OF ABBREVIATIONS

IDR	-	Interstorey Drift Ratio.
Mw	-	Moment Magnitude
N-S	-	North - South
NW-SE	-	North West – South East
RSA	-	Response Spectrum Analysis
PGA	-	Peak Ground Acceleration

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CHAPTER 1

INTRODUCTION

1.1 Overview

An earthquake is a rapid movement of geological elements under the earth's surface that causes a weak or strong shaking on the ground. Tectonic plate boundaries cause the action. Based on Figure 1.1, the hypocenter is the focus place within the earth where the earthquake occurred, and the epicenter is the point on the earth's surface roughly above the focus. The earthquake hazard is the most intermediate threat to the world's and Malaysia's health, safety, and economic viability. Every time an earthquake occurs, it shows the consequences that such catastrophic catastrophes pose to contemporary industrial society, impacting everything from enormous loss of life to infrastructure damage and financial instability.

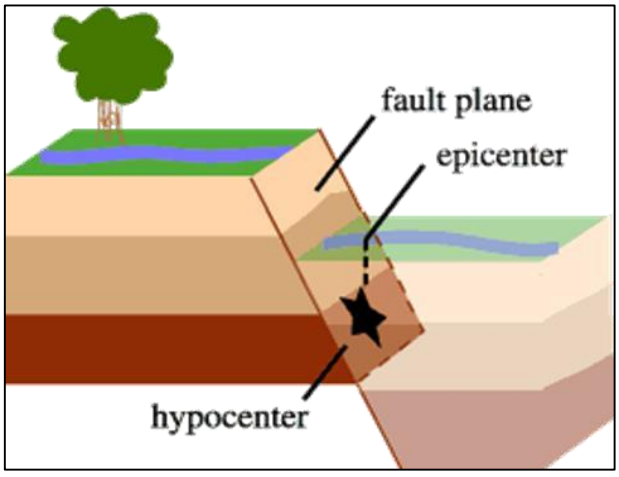

Figure 1.1 : The tectonic plate boundary

Source : U.S. Geological Survey (n,d)

Every time the earthquake occurs, the strength will be varied, and it is classified as magnitudes scale. The magnitude of an earthquake is proportional to the quantity of seismic energy emitted at its epicenter. It is based on the amplitude of earthquake waves measured by sensors with a consistent calibration. The earthquake's intensity varies depending on its location, where it can be classified into two (2): interplate and intraplate. An interplate earthquake occurs along a plate boundary and causes minor tremors with a shorter recurrence time. Meanwhile, an intraplate earthquake happens within the interior of a tectonic plate and causes severe tremors with a longer recurrence time.

Malaysia is a country that has two (2) regions separated by the south china sea. The classification of earthquakes in Malaysia has a different category for both the Peninsular and Borneo region where peninsular is intraplate, Sabah and Sarawak are interplate and intraplate (Loi et al., 2018). Sabah is classified as zone 1 and 2, Sarawak is classified as zone 2, and Peninsular is classified as zone 3. The seismic zones in Malaysia are also different, where the zones range from zone 1 to zone 3. Every zone is characterized by the Peak Ground Acceleration (PGA), equal to the most significant ground acceleration that occurred during earthquake shaking. It can be simplified that the smaller the number of seismic zones, the higher the rate of earthquake activity there.

In Malaysia, the most violent earthquake ever recorded occurred in Ranau, Sabah, on June 5, 2015, with a magnitude of 6.0. Figure 1.2 shows a landslide occurring in Ranau caused by the earthquake. The overall number of deaths was 18 persons, with 11 wounded. Over 2.84 billion dollars lost was estimated for building and infrastructure damage, landslides & geological changes. There was so much damage that almost all buildings in Ranau were affected by the earthquake, especially an essential building like a school.

The UMS geologist expert Professor Dr. Felix Tongkul had predicted that more earthquakes were expected for Sabah soon following the deadly Ranau 6.0 magnitude temblor on June 5, 2015 (Kristy Inus, 2017). He also said that more minor earthquakes would be expected to happen soon, which could be a positive sign of a massive earthquake. In early September 2017, two minor earthquakes struck

different parts of Sabah, which are at Tawau and Ranau. Therefore, more safety prevention should be emphasized because the building design nowadays was already not relevant to be used as we should consider the aftereffect of the earthquake.

Figure 1.2 : 6.0 magnitude of Ranau earthquake

Source : Stephanie Lee (2015)

1.2 Problem Statement

Seismic design is critical in structural analysis when a structure is exposed to earthquake ground motions. This ensures the facility continues to operate and fulfill its purpose even after the earthquake. Most of the existing buildings in Malaysia, including Sabah, were designed based on British Standards which the seismic element is not taken into consideration. This is shown from the 2015 Ranau earthquake, where almost all the buildings suffered severe damage due to the design that could not withstand the tremors from the quake.

The current studies on earthquakes in Sabah focus on the deformation of existing buildings located in the Ranau area. However, the studies on the performance level of the existing building in Sabah except Ranau area, due to earthquakes are still lacking. Therefore, this matter should be addressed because if the building collapses, many lives would be threatened, especially buildings with a high number of

occupants. Because of that, this study focuses on analyzing different height of buildings which are 3-storeys and 5-storeys. one of the buildings was located in UMS, the Kolej Kediaman Tun Mustapha with 3-storeys height and the other one was located in SMK Desa Wawasan, Tambunan, the Quarters to find out the performance level of the buildings while using various PGA values of the 2015 Ranau earthquake as a reference.

1.3 Objective of Study

This paper aimed to investigate the performance level of 3-storeys Kolej Kediaman Tun Mustapha and the Quarters at SMK Desa Wawasan, Tambunan based on the simulation from 2015 Ranau earthquake. The following objectives are listed in order to attain the research aims.

a) To examine the structural deformation of 3-storeys Kolej Kediaman Tun Mustapha and the Staff's Quarters at SMK Desa Wawasan, Tambunan due to various PGA values of 2015 Ranau Earthquake.
b) To determine the safety status of 3-storeys Kolej Kediaman Tun Mustapha and the Staff's Quarters at SMK Desa Wawasan, Tambunan after the earthquake.

1.4 Significance of Study

The findings of this study will provide the following knowledge;

a) Insight to the performance of an existing building to the engineer when faced with the earthquakes.
b) Measures to tackle or prevent this matter in order for the damage and casualties to be reduced.
c) Awareness to all engineers of the importance of the inclusion of earthquake elements in the design.

1.5 Scope of Study

This study will focus on the deformation analysis of 3-storeys Kolej Kediaman Tun Mustapha and the 5-storeys of Staff's Quarters at SMK Desa Wawasan, Tambunan subjected to various PGA values of the 2015 Ranau earthquake. These building were selected because it has a high number of occupants of UMS students and staffs at SMK Desa Wawasan. The first building was located on a 999-acre site near Sepanggar Bay, Kota Kinabalu, Sabah, Malaysia. This block has 3 floor levels with a total area of 290.4 m^2. The second building was located on Pahu Sintuong – Tuong road, 89657 Tambunan, Sabah. This block has 5 floor levels with a total area of 268.0 m^2.

For the first objective, the examination of the structural deformation of the building was carried out by modelling the structure using computer software, which is a PROTA STRUCTURE software. This software was used to perform a loading analysis for both buildings. Then, the modelled structures will be analysed again with Response Spectrum Analysis (RSA), and the PGA values that will be used was from the 2015 Ranau earthquake. The output from this analysis were from the lateral displacement and the interstorey drift ratio (IDR).

The output from the first objective, Interstorey Drift Ratio, was used to measure the performance level of the buildings. For the second objective, the safety status of the building was determined by focusing on the changes that occur on the storey that are affected the most due to the earthquake. Then, the outcome will be used to evaluate the safety status using standard FEMA 356 (2000).

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter provides an overview of the earthquake parameters and design analysis of structure due to seismic hazard which is divided into several subchapters. In addition, the history of earthquakes in the world and across Malaysia are also discussed. This chapter also includes an overview of the design philosophy where it states the aim of the earthquake design and performance of design structure due to earthquakes and the methods used in earthquake analysis. Lastly, the studies of earthquakes also will be reviewed based on the selected journal for this study.

2.1 Earthquake Overview

An earthquake is the shaking of the surface of the earth as a result of a sudden release of energy from within that creates seismic waves. The displacement of the Earth's crust (plate) is the most common source of earthquakes. The type and size of earthquakes that occur in a given location over time are referred to as their frequency. A seismometer is used to measure earthquakes. The most prevalent scale on which an earthquake occurs is the moment magnitude scale. The Richter scale is a local scale of 5 magnitudes that has been reported by the national seismological observatory. As long as the numerical ranges are valid, both scales are equivalent. Earthquakes with a magnitude of 3 or above are usually undetectable, while those with a magnitude of 7 or higher have a higher chance of causing catastrophic damage over vast areas, depending on the depth of the quake. The intensity of vibration was assessed using a modified Mercalli Scale.

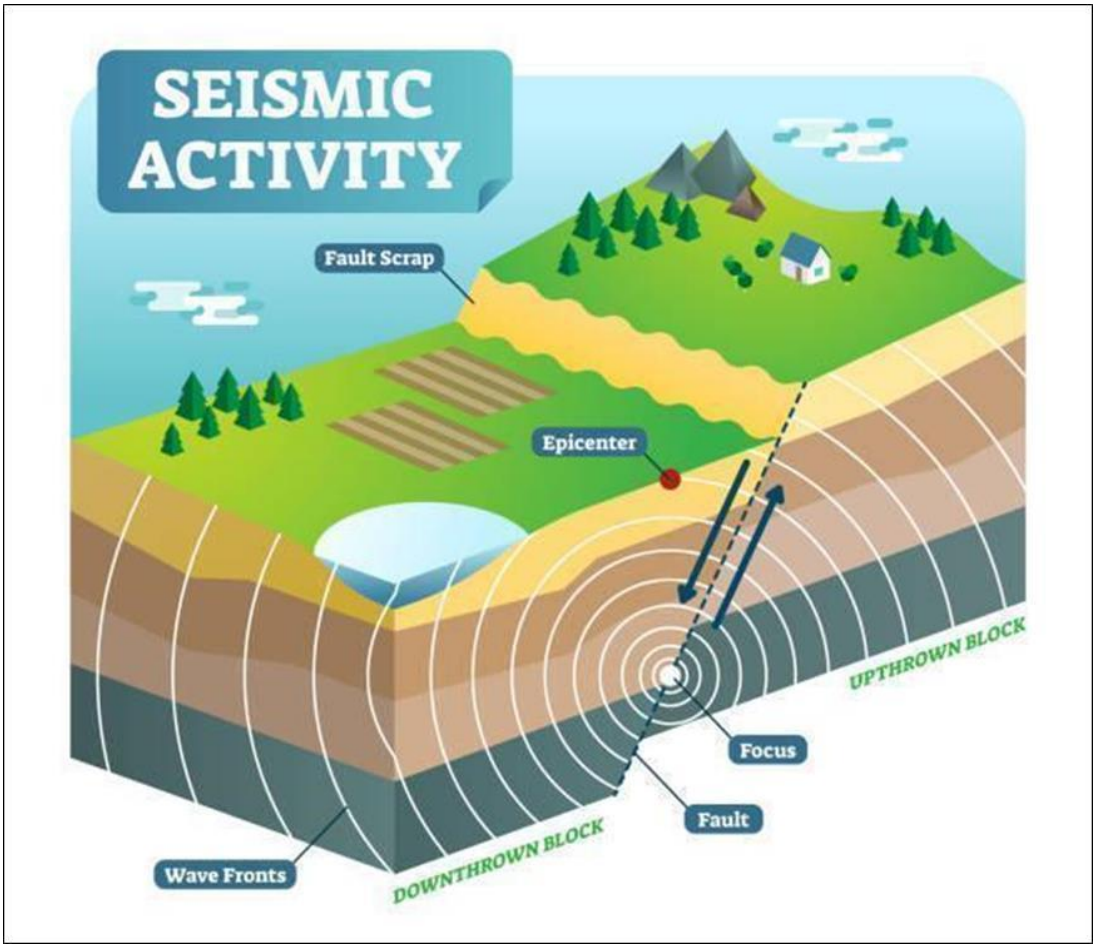

Figure 2.1 : Seismic Activity

Source : VectorMine (n,d)

The abrupt release of stress along faults in the earth's crust causes earthquakes, as shown in figure 2.1. The constant movement of the tectonic plates builds pressure in the rock strata on both sides of the fault until it reaches a critical level, at which point stress is released in jerky and rapid movement. These seismic energy waves travel through the ground and across the surface, creating the shaking experience known as earthquakes.

There are also several scenarios that cause earthquakes to occur like when the earth's crust has the ability to bend and fold. The hard rock breaks into blocks along the weak zone when this process occurs. Faulting is a movement that occurs when two sections of a rock clash horizontally or vertically. Faulting might take place on a local or large scale. Small-scale faulting normally happens deep beneath and is not observable from the surface.

Earthquakes can also be caused by isostatic bounces. The submerged soil, which is coated by a thick and heavy layer of ice, bounces back up because the ice layer at the top has melted or changed, resulting in an isostatic bounce. The isostatic bounce movement will continue to cause earthquakes until the earth's crust reaches a uniform pressure.

Next, human activities such as the construction of large-scale dams can also generate earthquakes. The total volume of water stored produces strong pressure on the earth's crust at the dam's bottom, generating an isostatic bounce that causes an earthquake until the earth's crust is uniformly pressured.

2.2 Classification of Earthquakes

Earthquakes are most likely to occur near or along the plate borders where the plates collide. Earthquakes are classified into two (2) which are interplate earthquakes and intraplate earthquakes as shown in Figure 2.2. Interplate earthquakes occur along the edges of the interacting plates, contributing more than 90% of the world's release of seismic energy. Most of the world's largest earthquakes have originated in the subduction regions as a result of the thrusting of one plate under another. Interplate earthquakes create tsunamis, which can have magnitudes exceeding 8 and cause widespread devastation and destruction. Interplate earthquakes are often seen at high seismic zones, which are located near the ones with more earthquakes. Examples of high seismic zones that are commonly seen or heard are California, Chile, Indonesia, and Japan.

Intraplate earthquakes are earthquakes that occur within the plate. Although the magnitude of these earthquakes is small, they have the potential to cause fatalities if they strike near susceptible metropolitan centers. Strain energy is stored within the plates as a result of plate movement. Intraplate earthquakes occur when weak portions of the bedrock can no longer withstand the energy and slip. Plate boundaries produce the most powerful earthquakes, which are also more often than interplate earthquakes. Earthquakes that occur within the interiors of tectonic plates make up fewer than 10% of all earthquakes and rarely reach magnitude 8. They are