SEISMIC PERFORMANCE OF WATER TANK TOWER

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DEDICATION

"…. teristimewa buat mama dan ayah,

Puan Adzura Abdullah dan Encik Ismail Ishak,

ini adalah hasil titik peluh anakmu…

kepada kakak dan adik-adik tersayang,

Zira, Keyi, Radi, Zana, Ashraf, dan Wani

ini adalah hasil usaha Apis di menara gading…

dan kepada rakan-rakan seperjuangan,

ini adalah usaha kita bersama

…."

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"Sekalung budi setinggi-tinggi penghargaan"

TERIMA KASIH SEMUA.

- Fadrul Hafiz Bin Ismail -

ABSTRACT

A water tower consists of an elevated water tank and a shaft. Purpose of water tank tower is storage of a certain quantity of water at sufficient pressure for transporting water over certain distance. Water tower's design should be able to resists lateral load if earthquake occurs. Earthquake is a sudden movement of the earth caused by the abrupt release of strain that has accumulate over a long time. This dynamic vibration of lateral movement affects structures strength and behaviors. Thus, this study is based on seismic performance of water tank tower structure during earthquake and the objective is to determine the behavior of structure using computer software. Scope of this study is seismic performance effect on water tank tower around Malaysian region due to the nearest earthquake loading. The tower will be design and analyze using SAP 2000 and will produce structure behaviors according to the maximum earthquake loading. The findings and result analysis gained from this study can be use as reference, and be researched further focusing on improved design of water tank tower and less structure damage can be expected when earthquake loading occurs.

ABSTRAK

Menara air terdiri daripada tangki air dan struktur di bawah tangki. Tujuan menara air dibina adalah untuk menyimpan air dalam suatu kuantiti yang diperlukan pada suatu ketinggian yang sesuai bagi tujuan agihan di suatu kawasan. Rekabentuk menara air perlu dibina dengan kekuatan yang mampu ditanggung daripada beban gempa bumi. Gempa bumi didefinisikan sebagai pergerakan secara tiba-tiba diantara kerak bumi yang disebabkan oleh tekanan yang ditanggung dalam suatu jangka masa dan membentuk getaran dinamik. Getaran dinamik membentuk pergerakan sisi yang menyebabkan kesan terhadap kelakunan dan kekuatan suatu struktur terganggu. Dalam hal ini, kajian ini bertujuan mengkaji kesan seismik terhadap menara air apabila gempa bumi terbentuk dan objektif kajian ialah untuk melihat kesan kelakunan struktur menara air dengan menggunakan perisian komputer. Skop kajian ini ialah kesan seismik terhadap menara air di Malaysia hasil gempa bumi daripada negara jiran. Menara air akan direkabentuk dan dianalisis menggunakan perisian komputer SAP2000 dan fokus kepada kelakunan struktur menara terhadap beban gempa bumi paling optimum. Hasil keputusan daripada kajian boleh digunakan sebagai rujukan bagi tujuan lanjutan kajian dan membaik pulih kajian terhadap menara air di Malaysia bagi mengurangkan kemusnahan pada struktur menara daripada beban gempa bumi.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF CHARTS

LIST OF SYMBOLS

$\ddot{u}$	Acceleration with respect to time
u	Displacement, initial displacement $u(0)$
m	Mass of the structure
k	Stiffness of the structure
$p(t)$	External force varies with time
f_D	External force of the damper equal and opposite with the internal force in the damper
c	Viscous damping coefficient
$\dot{u}$	Velocity varies with time
f_S	External force equal and opposite to the internal force resisting the displacement, u
k	Lateral stiffness of the system
u	Displacement varies with time
u_g	Displacement of the ground
$u^t(t)$	The total (or absolute) displacement of the mass
$u(t)$	The relative displacement between the mass and ground
ω_n	Natural circular frequency
T_n	Natural period of vibration
f_n	Natural cyclic frequency of vibration
f_{rf}	Flexural Strength of concrete
f_{rs}	Shear Strength of concrete
E	Modulus of Elasticity
f_{cu}	Concrete Compression Strength

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Water is human basic needs for daily life. Sufficient water distribution depends on design of a water tank in certain area. An elevated water tank or water tank tower is a large water storage container constructed for the purpose of holding water supply at certain height to pressurise the water distribution system. Pressurisation occurs through the elevation of water on the tower height as per requirement of the distribution system. Water tank should be placed at the highest point and at the centre of the pipeline system. Size of water tank depends on the quantity of water needed at the maximum daily peak usage.

The first water supply system complex was developed in Germany in the middle of the 19th century, leads to an important improvement in hygenic standard. A central element of this modern water supply system was the water tank tower. This is where water storage and elevation of water were united for the first time. In the beginning of 1900 , and thirty to forty years later the largest number of water tower were built when the villages and cities were equiped with public water distribution system. When comes to 20th century, many tall building was built and the water tank tower starts to lose their importance as the tanks were incorporated within the

building. However, water tank tower still presented asthetically to the industrial and town development of certain places in some countrries and remain with its design elements of structure. (Sara Hamm, 2004)

Apart from the design of water tank tower structure, the main purpose of its built is to distribute water effectively and sufficiently. Water is important to human being for their daily usage in residential and commercial service. It being important, we should think of what will happen to water tank tower if earthquake occurs?

Earthquake was proven to cause worst phenomenon that can happen in human life with a lot of damages. Earthquake happened when two tectonic plates moved or slipped from its placed and produced energy that transfered to the earth's surface. The energy is transform into a seismic wave or vibration of the ground motion. The ground acceleration from the wave are recorded and keep as time history analysis data.

Based on seismotechnic setting map, Malaysia is located outside of earthquake active zone. However, there is still a small percentage effect on earthquake vibration that would reached Malaysia because of its location surrounded by active earthquake zone. The nearest seismically active faults around Malaysia are Indonesia and Philippines archipelagos as well as in the east and northeast of Sabah (Azlan, 1999).

Therefore according to the above situation, Malaysia shall not be considered as one of the totally free vibration country or totally safe from earthquake. Structure design within Malaysian region must include the seismic effect which will increase the safety factor of the structure including the structure of the water tank tower. This paper is written to elustrate the analysis from a study an effect to a water tank tower design in Malaysia when earthquake vibration occurs.

1.2 PROBLEM STATEMENT

It is known that water tank tower in Malaysia have low intensity of seismic influence effect. The conventional structure design does not include the seismic loading. Therefore, this study is conducted to observe the effect and the performance of the water tower structure to resist the earthquake loading.

1.3 OBJECTIVE OF STUDY

The objectives of this study are:

(a) To study the dynamic characteristic of the structure.
(b) To determine the behavior of water tank tower structure when earthquake occurs.
(c) To compare performance of structure under seismic loading with the design capacity of the water tank tower.
(d) To compare the performance of structure using SAP2000 software with the theoretical calculation.

1.4 SCOPE OF STUDY

The scope of study is limited to only one type of water tank tower structure. The tower is analyzed using SAP2000 to see the behavior of the structure so that it can be designed with less structural damages caused by earthquake vibration. The result from SAP2000 will be compared with the theoretical calculation method using Microsoft Excel as a medium to solve the problem. The water tower's located at UITM Shah Alam, Selangor is taken as a model for this study and the earthquake data for analysis purposes is taken from RapidKL's data simulation for seismic hazard assessment for Malaysia Region.