SEISMIC BEHAVIOUR OF TUNNELS WITH DIFFERENT SOIL TYPES AND DEPTHS

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ABSTRACT

Effect of seismic wave towards the tunnel as underground structure could cause unforeseeable damages during earthquake event. The waves that transmitted through the soil medium would affect the behaviour of the tunnel depending on the soil properties. The scope of this study will focus on tunnel structures in Malaysia; namely the SMART Tunnel and RAPID Tunnel. The objective of this study is to investigate the performance of the said tunnels under seismic load with different soil layer types and depths. These tunnels were modelled using finite element method (FEM) under dynamic analysis approach. Time history analyses were performed with several peak ground acceleration values, ranging from 0.05g, 0.10g, 0.15g, 0.19g and 0.25g. From this study, it was revealed that different soil properties surrounding the tunnel would affect the seismic behaviour of underground tunnel significantly. Nevertheless, both tunnels are capable to resist the earthquake loading compared with the design capacity of the tunnels.

ABSTRAK

Kesan gelombang sismik terhadap terowong terutamanya sebagai struktur bawah tanah boleh menyebabkan kesan kurang dilihat ketika gempa bumi berlaku. Namun, gelombang yang dipindahkan melalui medium tanah akan mempengaruhi kelakuan terowong yang bergantung terhadap sifat tanah. Kajian ini akan memfokuskan terowong di Malaysia iaitu terowong SMART dan RAPID .Tujuan kajian ini dijalankan adalah untuk mengenalpasti tahap kelakuan terowong yang berkenaan akibat gempa bumi dengan pelbagai kedalaman dan jenis tanah. Melalui analisis dinamik, terowong ini dimodelkan menggunakan kaedah teori unsur tak terhingga. Analisis 'Time History' dijalankan dengan mengenakan beberapa kekuatan gempa bumi iaitu dari 0.05g, 0.10g, 0.15g, 0.19g dan 0.25g. Hasil kajian menunjukkan sifat tanah yang berbeza dikeliling terowong mempengaruhi kelakuan terowong. Walaubagaimanapun, kedua-dua terowong berupaya menahan beban gempa bumi jika dibandingkan dengan kapasiti rekabentuk terowong.

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E	=	Young Modulus
Vs	=	Shear wave velocity
N	=	Standard Penetration Test Number
I_c	=	Moment of inertia of tunnel lining section
C_s	=	Apparent velocity of S-wave propagation
G_m	=	Shear modulus of soil
I	=	Second Moment of Area
M	=	Maximum Moment Capacity
S	=	Maximum Shear Capacity
ρ_m	=	Density of medium
g	=	Gravity acceleration
T	=	Natural Period
γ	=	Soil unit weight
r	=	Radius of circular tunnel
h	=	Thickness of soil deposit
A_c	=	Cross sectional area of tunnel lining
L	=	Wavelength of ideal sinusoidal shear wave
Q_{max}	=	Maximum axial force in tunnel cross section
K_a	=	Longitudinal spring coefficient of soil or rock medium

K_t = Transverse spring coefficient of soil or rock medium

v_m = Poisson's ratio of soil medium

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CHAPTER 1

INTRODUCTION

1.1 General

It is most common opinion that underground structure will safe during earthquake. This is because their responses to earthquake loading are less damage compare with surface structure. Underground structures are constrained by the surrounding medium (soil or rock). It is unlikely that they could move to any significant extent independently of the medium or be subjected to vibration amplification.(Wang,1993)

Nowadays, tunnelling in soft ground is become a common geotechnical activity for urban transportation or water management facilities in many large cities around the world. For this reason, the determination of the dynamic response of the tunnel in soil to seismic waves is important.

1.2 Earthquake Effect on Underground Structure

Earthquake effects on underground structures can be grouped into two categories which is ground shaking and ground failure such as liquefaction, fault displacement and slope instability. Ground shaking refers to the deformation of the ground produce by seismic waves propagating through the earth's crust. The major factors influencing shaking damage include the shape, dimensions and depth of the structure , the properties of the surrounding soil or rock, the properties of the structure and the severity of the ground shaking (Dowding and Rozen, 1978)

1.3 Problem Statement

Eventhough tunnel were considered as safest structure under earthquake loads but there has been increasing awareness of seismic hazards for underground structures (Merit,et al. 1985). This study is important to enhance awareness of seismic hazards of tunnel. Furthermore, this study could be a guideline in designing the tunnel that combines geotechnical and structural engineering point of view.

It is important to know the behaviour of the tunnel that embedded with different soil layer and depth because it reacts differently with earthquake loading. Therefore, this study are important as it will study the value of ground motion acceleration at the tunnel lining which will varies with different soil type and depth.

1.4 Objective of study

The objectives of the study are:

1. To determine the ground accelerations of tunnel models under various type of intensity.
2. To investigated the capability resistant of the tunnel.

3. To identify the performance of the tunnel under various earthquake intensities.

1.5 Scope of study

In this study the scope can be divided into these following:

i) This study will focus on tunnel structures in Malaysia which is SMART Tunnel and RAPID Tunnel

ii) Modelling circular tunnel embedded in different soil layer and depths.

iii) Modelling circular tunnel with spring connection in different soil layer and depths.

iv) Modelling the tunnel with depth of 5m,10m,15m and 25m.

v) Analyzing the tunnel with various earthquake intensities of 0.05g, 0.10g, 0.15g, 0.19g and 0.25g

1.6 Research Methodology

The methodology of the study are explained as follows with flowchart of methodology as shown in Figure 1.1:

Stage 1: *Clarification of the project on the objectives and scopes of the study*
This is to verify the feasibility of the study outcomes and planning of methodologies.

Stage 2: Literatures, collecting data
In this stage, data such as detailed drawing and soil investigation reports have been collect. Other parameter from the soil is required such as thickness of soil layer, SPT- Number, shear wave velocity and other control data that have to be identify.

Stage 3: Modelling of structure

Knowing the performance of tunnel structure under earthquake loading is essential to assume the structure behave accordingly to literature finding.

Stage 4:Ground response analysis

The analysis was carried out by using nonlinear one dimensional shear wave propagation analysis approach by using Nonlinear Earthquake Site Response Analysis (NERA) program. The ground response analysis was performed by propagating the strong motion data at the bedrock through each soil profile with the NERA program. Synthetic time history of Kuala Lumpur with various intensities of 0.05g, 0.10g, 0.15g, 0.19g and 0.25g were applied as input data

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Stage 5: Analysis of finite element modelling

Finite element modelling using SAP2000 computer program are used to analyze the tunnel. Two cases of tunnel are model in linear and nonlinear analysis. Linear analysis is by modelling circular tunnel with spring connection in 4 type of subsoil model with depth of 5m, 10,15m and 25m from tunnel crown. For nonlinear analysis is by modelling circular tunnel in 4 type of subsoil model with depth of 5m, 10m, 15m and 25m from tunnel crown. Earthquake loading from synthetic time history of Kuala Lumpur were used with intensities of 0.05g, 0.10g, 0.15g, 0.19g and 0.25g.

Stage 6: Performance Analysis

The performance of tunnel had been study by looking at the displacement, normal stress and shear stress from the analysis. The result will be compared with the design capacity of the tunnel system.

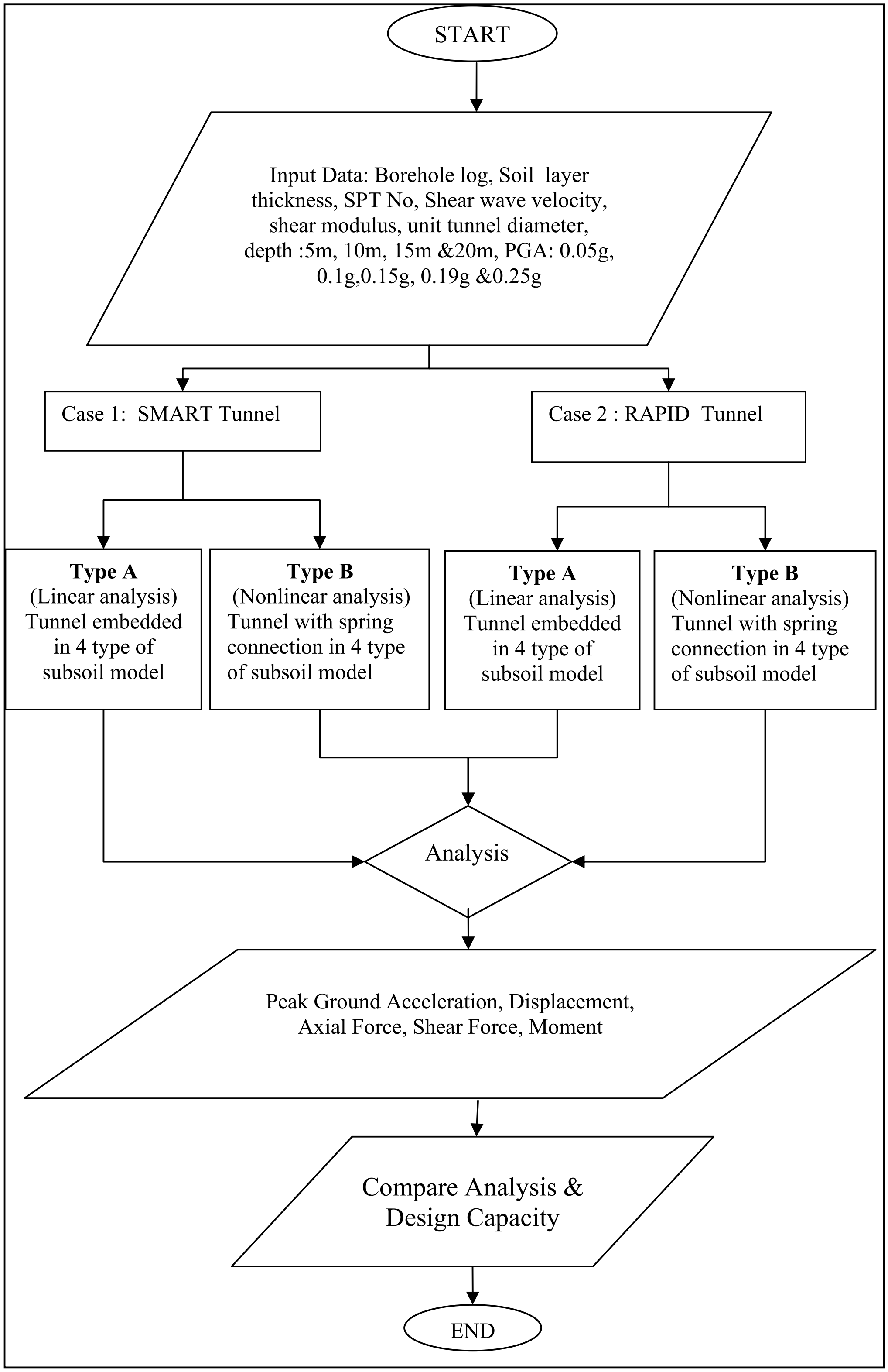

Figure 1.1 : Research Methodology Flowchart

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