NON LINEAR SEISMIC PERFORMANCE OF SMART TUNNEL

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Special Thanks…

To My Beloved Wife …

Syahirul Akmal Binti Ani@Mahbar

To My Beloved Family …

Haji Wan Ahmad Bin Wan Su

Hajjah Zabariah Binti Yahya

Wan Saiful Amin Bin Wan Ahmad

Aida Hayati Binti Wan Ahmad

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ABSTRAK

Projek Terowong Jalan Raya dan Pengurusan Air Banjir (SMART) di Kuala Lumpur (KL) melibatkan proses rekabentuk dan pembinaan yang bertujuan untuk lalulintas dan juga laluan perparitan. Bahagian-bahagian daripada terowong ini direkabentuk dan dibina untuk dua tujuan utama; pertama, jalan bertingkat adalah untuk menyelesaikan masalah lalulintas yang sibuk di Bandar Kuala Lumpur dan juga untuk mengurangkan masalah banjir. Terowong ini dibina menggunakan beberapa teknik seperti ‘bored’ dan ‘cut & cover tunneling’. Terowong ini juga mempunyai dua simpang bawah tanah untuk membenarkan kenderaan keluar dan masuk. Terowong adalah salah satu struktur bawah tanah yang terbesar dan merupakan struktur paling selamat semasa berlaku gempa bumi. Walaupun terowong adalah lebih selamat berbanding struktur lain, kajian ini amat penting untuk meningkatkan kesedaran tentang bahaya kesan gempa bumi terutamanya di Malaysia. Satu perisian iaitu SAP 2000 akan digunakan dalam kajian ini berasaskan kaedah teori unsur tak terhingga. Analisis dijalankan berdasarkan garis lurus analisis ‘Time History’ dan Respons Spektra. Untuk tujuan semakan, keputusan daripada analisis unsur tak terhingga akan dibandingkan dengan rekabentuk kapasiti terowong.

ABSTRACT

The storm water management and road tunnel (SMART) project in Kuala Lumpur (KL) involves the design and construction of a road and drainage tunnel. A portion of tunnel is designed and constructed for dual purpose; firstly, a double deck road tunnel to serve the increasing volume of traffic in the busiest district of KL city and also to alleviate floods. The tunnel were constructed using several techniques such as bored and cut & cover tunneling. There are also two underground junction boxes to allow vehicle entry and exit from the motorway tunnel and two ventilation shafts. Tunnels as one of the biggest underground structures are well known as the safest structures during earthquakes. In theory, tunnel has the lower rate of damage compared than other surface structures. Even though tunnel are much safer compared than surface structures, this study are important to enhance awareness of seismic hazards for tunnel especially in Malaysia. The existing structural analysis application called SAP 2000 has been used in this study based on the theory of finite element method. The analyses are conducted in linear time history and response spectrum analysis. For checking purposes, the result from finite element analysis will be compared with tunnel design capacity.

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CHAPTER I

INTRODUCTION

1.0 INTRODUCTION

An earthquake is produced by the sudden rupture or slip of a geological fault. Faults occur at the intersection of two segments of the earth's crust. Peninsula Malaysia lies in the Eurasian Plate and also within the Indian-Australian Plate. Geologically, small faults also exist in East Malaysia. Records have shown that we do sometimes experiences some off-set tremors originating from the Indonesian zone. Thus there is a need for some seismic checking to be incorporated in the design process so that the tunnels and structures would be resistant to earthquake

Tunnelling activities in Malaysia are related to a number of applications such as for civil engineering constructions like tunnels for highways and railways, and diversion tunnels in water supply and pressure tunnels in hydro power generation, underground mining and quarrying; storage facilities, etc. and of late sewage tunnels. Ting et al. (1995) summarized the tunnelling activities in Malaysia up to 1995.

Table 1 summarizes the tunnelling activities during the last decade (1995-2005) forvarious rock formations in Peninsular Malaysia. It can be seen that most of the tunnels uses the drill and blast method. The significant advancement made is the innovative use of TBM technique in the SMART tunnel construction to overcome the problems posed by the treacherous Kuala Lumpur Limestone Formation.

Table 1.1 Tunneling Activities From 1995 To 2005

ITEM	NAME OF THE PROJECT	APPLICATIONS	GEOLOGY	OBSERVATIONS
1	Sg. Selangor Dam (water supply)	Division Tunnel	Granite / faulting	Excessive overbreak D & B, completed 2003.
2	SMART	Dual Flood Mitigation/Roadway	Limestone / Alluvium	Sinkholes, etc. TBM
3	Karak Highway	Highway Twin Tunnels	Granite	D & B, 1997.
4	Kelinci Dam (water supply)	Water Transfer Tunnel	Granite / fault	TBM, 1996.
5	Pergau Dam (hydroelectric)	Division & Pressure Tunnels, Powerhouse	Granite mostly, minor metasediments	Low ground stresses, Hydrothermal alteration D & B, 1997.
6	Penchala Link	Highway Twin Tunnels	Granite / fault	Some collapse, add. support; D & B, 2004.
7	K.L.L.R.T.	Subway Twin Tunnels	Limestone / Kenny Hill fm (metasedm and skarn)	Sinkholes / hard skarn of 270 MPa UCS. TBM, 2000.
8	Beris Dam (water supply)	Division Tunnel	Sedimentary	5m Dia x 200m long diversion tunnel D & B, 2001.
9	Kinta Dam (water supply)	Division Tunnel	Granite	D & B.
10	Bakun Dam (hydroelectric)	Division & Pressure Tunnels	Sandstone / shale	D & B.
11	Interstate Water Transfer Scheme	Water Transfer Tunnel	Granite	45km long tunnel connecting new dam in Pahang to Langat dam in Selangor

1.1 TUNNEL SEGMENT SMART TUNNELS

SMART is an acronym for Stormwater Management and Road Tunnel, a project under the Federal Government initiated to alleviate the flooding problem in the city centre of Kuala Lumpur, Malaysia. The project is implemented through a joint venture pact between MMC Berhad and Gamuda Berhad with Department of Irrigation And Drainage Malaysia and the Malaysian Highway Authority as the executing government agencies. (SMART, 2006)

The SMART tunnel is an innovative and cost-effective solution that combines two distinct problems in Kuala Lumpur which is the major floods that caused by heavy rains during the monsoon season and severe traffic congestion along city streets during peak hours.

The SMART tunnel is a dual-purpose tunnel designed to cater for flow of water and ease traffic congestion in the Kuala Lumpur city. The total storm water tunnel length is 9.7km with 3km of motorway having two levels of traffic deck within the storm water tunnel. The upper deck provided traffic lanes flowing South while the lower deck provided traffic lanes flowing North.

1.2 PROBLEM STATEMENT

For along time, we have known that Malaysia are safe from earthquake disaster since Malaysia were in the earthquake-free zone. Eventough Malaysia is regarded as stable but still face slow magnitude earthquake in Bukit Tinggi, Pahang and it’s have reveal that Malaysia are not free from seismic activity.

Furthermore, if earthquake occur in the nearby country such as Indonesia, Malaysia will also get the impact. Azlan (2007) stated that Peninsular Malaysia does lie on faults but have been known to be non-active faults. Malaysia is located in low seismic activity area but the active earthquake fault line through the centre of Sumatera just lies 350 km from peninsular.

Therefore when the earthquake occurs, the building or any structures face some unpredicted risk from earthquake hazards. Since most of the building in Malaysia does not include earthquake factor in their design consideration, this study is important to increase the awareness of earthquake design consideration.

1.3 OBJECTIVES

The objectives of this study are :

1. To study the dynamic characteristics of SMART Tunnel
2. To determine the behaviour of SMART Tunnel when earthquake occur.
3. To compare performance of structure under seismic loading with the design capacity of SMART Tunnel.

1.4 SCOPE OF STUDY

The scope of this study are :

1. Study architecture, structural and detailed drawing of SMART Tunnel.
2. Study the Soil Investigation Report of SMART Tunnel
3. SMART Tunnel is modelled using SAP 2000 computer software.
4. Modelling the tunnel using plane strain modeling
5. Perform dynamic loads from earthquake loads using non linear analysis.

1.5 RESEARCH METHODOLOGY

The research has been done based on the Figure 1.6.1. Before modelling the tunnel using SAP 2000 program, data from SMART Tunnel such as detailed drawing and soil investigation report have been collect. The others parameter needs in SAP 2000 program like material properties, dimension, load acting on tunnel lining, tunnel shape and other control data have to be identify. After the tunnel is model, it been analyze with earthquake loading from actual ground acceleration. Then tunnel model will be compare with design capacity to check the performance of the tunnel during earthquake.

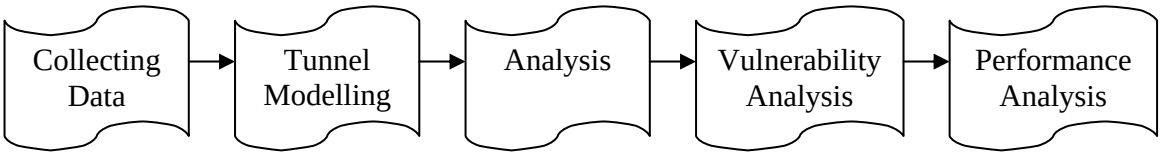

Figure 1.6.1 : Process Of The Research

The analysis that will be do in this research are response spectrum analysis, time history analysis and dynamic non linear analysis. Response spectrum analysis is performed to study the peak response of structures under earthquake loading. The earthquake responses studied include shear forces and axial force. For the time history analysis, the actual time history is taken as the earthquake ground motion.

For dynamic non linear analysis, since damage potential and ultimate failure can usually be directly related to the inelastic displacement capacity of the structure, in recent years there has been a shift of attention away from linear methods of seismic analyses to nonlinear methods which put emphasis on the displacements within the structure. Thus, nonlinear methods of analysis that are capable of realistically predicting the deformations imposed by earthquakes on structures are needed. In response to this need, SAP 2000 computer software is used to evaluate dynamic nonlinear analysis of the structure