FINITE ELEMENT ANALYSIS ON ENERGY ABSORBING CAPABILITY OF W-BEAM CORRUGATED GUARDRAIL

By:

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DECLARATION

This work has not previously been accepted in substance for any degree. I hereby declare that the work reported in this thesis is the results investigated by my own and not being plagiarized from any external sources. Information and other sources are acknowledged by giving explicit references. Bibliography/references are appended.

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Symbols	Descriptions	Unit
F	Force of vehicle	N
m	Mass of vehicle	kg
K.E	Kinetic Energy	Joule
V	Velocity of impact	m/s
E	Modulus Elasticity	pa
δ	Stress	N/m^2
ε	Strain	m/m
εI	Incident Strain	-
εr	Reflected Strain	-
εt	Transmitted Strain	-
ΔL	Total length of the object changes	m
L_o	Original length	m
A_o	The original cross section area through which the force was applied	m^2

LIST OF NOTATIONS

Symbols	Descriptions
AASHTO	American Association of State Highway and Transportation Officials
BCC	Body Centre Cubic
BS	British Standard
CNC	Computer Numerical Controller
FCC	Face Centre Cubic
FE	Finite Element
NCHRP	National Cooperative Highway Research Program
PLUS	*Projek Lebuh Raya Utara Selatan* ,NORTH-SOUTH Expressway
REAM	Road Engineering Association of Malaysia
SHPB	Split Hopkinson Pressure Bar
UTM	Universal Tensile Machine
UTS	Ultimate Tensile Strength
WEDM	Wire Electrical Discharge Machine

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ANALISIS ELEMEN TERHINGGA TERHADAP KEUPAYAAN TENAGA PENYERAPAN BAGI REL ADANG RASUK W

ABSTRAK

Kemalangan jalan raya adalah salah satu fenomena masalah yang terbesar di dunia dan masalah bagi mencegah sesuatu kemalangan. Rel Adang seperti *W-beam Guardrail* adalah penghadang jalan yang direka untuk mencegah kenderaan dari meninggalkan jalan tersebut untuk meningkatkan keselamatan jalan raya. Kesan ujian skala penuh telah dan akan terus menjadi kaedah yang paling biasa menilai prestasi keselamatan rel adang, halangan lain dan bahagian tengah jalan raya. Tujuan kajian ini adalah untuk membangunkan dan menilai model skala penuh pengiraan halangan keselamatan jalan raya untuk digunakan dalam simulasi kemalangan dengan Perisian ABAQUS / EXPLICIT dan terus membandingkan keputusan pengiraan dengan data ujian. Di dalam kajian ini perubahan sifat atau karektor rel adang diperiksa menggunakan ujian spesimen makmal kedua-dua statik dan dinamik. Kemudian simulasi digunakan bagi menganalisa elemen rel adang secara analisa perlanggaran yang sebenar merujuk kepada laporan NHRCP 350. Ini adalah untuk mengenalpasti kesan ke atas sifat-sifat mekanikal Rel adang dan untuk menilai keupayaan tenaga penyerapan rel adang akibat impak perlanggaran.

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ABSTRACT

Road-traffic crashes are one of the world's largest public health and injury prevention problems. Median Barrier such as W-beam Corrugated Guardrail is a barrier on a road designed to prevent vehicles from leaving the roadway to improve road safety. Full-scale impact testing has been and will continue to be the most common method of evaluating the safety performance of guardrails, median barriers and others. The purpose of this research was to develop and evaluate a full-scale computational model of the road safety barrier for use in crash simulations with ABAQUS/ EXPLICIT Software and further compare the computational results with test data. In this present study the behaviour of W-beam guardrail is examined using laboratory specimen tests both statically and dynamically simulated using finite element analysis by analyzing the W-beam Corrugated Guardrail and Solid Car Bumper under crash condition based on NHRCP 350 reports. This is to identify the effects on mechanical properties of W-Beam Corrugated Guardrail and to describe as well the energy absorbing capability of W-Beam Corrugated Guardrail would produce after the crash impact occur.

CHAPTER 1

INTRODUCTION

1.1 Overview

The North-South Expressway (NSE), is the longest expressway in Malaysia with the total length of 722 km running from Bukit Kayu Hitam in Kedah near the Malaysian-Thai border to Johor Baharu at the southern portion of Peninsular Malaysia and to Singapore. The expressway as in Figure 1.1, links many major cities and towns in western Peninsular Malaysia, acting as the 'backbone' of the west coast of the peninsular. It is also known as PLUS Expressway, named after the highway's concessionaire, Projek Lebuhraya Utara Selatan Berhad (North South Expressway Project; abbreviated as PLUS).

Figure 1.1: Overview of North-South Expressway Berhad , (PLUS Expressway Berhad)

Most heavy vehicles are only allowed to travel 80–90 km/h by law. Considering that two lanes are inadequate for smooth traffic flow, the expressway is being widened as a result of the increasing number of fatal accidents along this highway. It has been recently decided that the two-lane 110 km/h highway will be upgraded to a three-lane 110 km/h highway. The highway widening project has been underway since 2006 as an accident-reducing measure. The installation of crash barrier along the NORTH-SOUTH Expressway Berhad (PLUS) as one of the highway appurtenance that is to keep cars on the road and in the appropriate lane of traffic. When a vehicles collides with the crash barrier, the barrier is supposed to gently push the car back into the roadway, ensuring that it does not run off the road or into another lane of traffic (Lu et.al,2003).

A crash barrier is a piece of traffic safety equipment which is designed to keep cars on the road and in the appropriate lane of traffic. There are number of crash barrier designs in use around the world, and the basic engineering of these barriers is periodically adjusted to address changing trends in car and road design.

One part of the overall strategy for reducing the fatalities and improving the roadside safely has been used of roadside safety appurtenance such as guardrails and median barrier in highways (Ray & McGinnis 1997).Guardrail can be used for tasks beyond keeping cars in the right place. They are often used in urban environments for safety, to keep cars out of restricted areas, and to increase security around vulnerable buildings. Although the goal of a guardrail is to push cars back into the road, these guardrails can fail. Poorly-constructed guardrails may collapse, allowing a car to run

over the guardrail and off the road or into traffic. Figure 1.2 shows the failed of w-beam guardrail as crash barrier upon high impact.

Figure 1.2: Examples of collision with guardrails at Northern Region
(PLUS Expressway Berhad)

In other cases, a guardrail designed for basic vehicle traffic may fail when it is hit by a truck which is larger and heavier than the barrier was engineered for. Motorcyclists are also vulnerable to accidents with guardrail, as they can be flipped over them and into oncoming traffic upon impact. Table 1.1 shows the casualty severity increases year by year and Figure 1.3 indicates numbers of fatalities forecast for Malaysia by year 2020.

Year	Total Accident	Casualty Severity		
		Fatal	Serious Injury	Slight Injury
2006	237	2	19	58
2007	319	6	38	64
2008	368	6	40	70

Table 1.1: Accident Statistic within Northern Region
(PLUS Expressway Berhad)

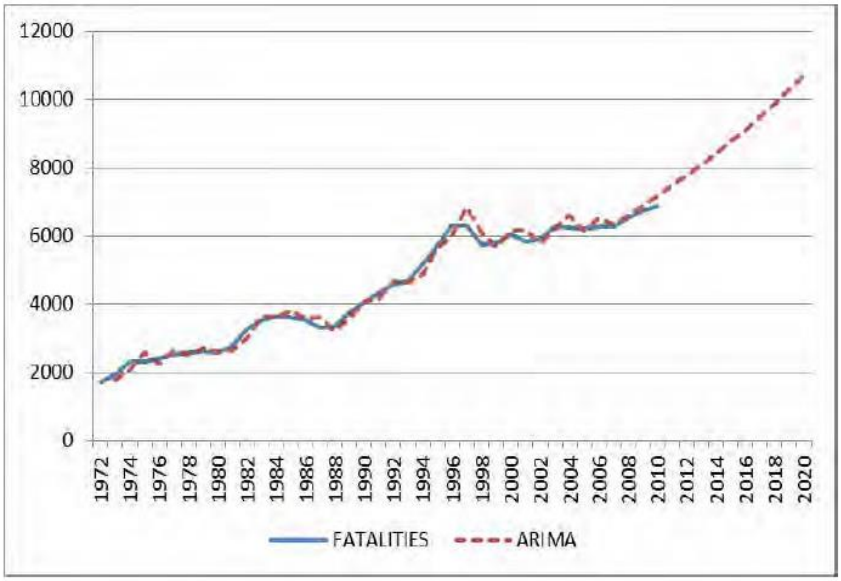

Figure 1.3: Fatality forecast for Malaysia (MIROS,2012)

The W-beam guardrail still plays the role of safety appurtenance in the expressway due to the higher absorbing of energy compares to the concrete. The design of the w-beam guardrail is generally to let the vehicle hit the barrier and steered back onto the road. This may be achieved by designing the supports to break off on impact, allowing the barrier to deform and push the vehicle back on track. In some cases cost cutting has led to a failure of this mechanism, with so-called "duck-nesting" (after the shallow nature of a duck nest) of barrier support bases. When this happens the supports tilt over at the base instead of breaking off, allowing the barrier to collapse and the vehicle to go over the barrier.