



UNIVERSITI PUTRA MALAYSIA

**DESIGN AND DEVELOPMENT OF GUARDRAIL FOR EXCLUSIVE
MOTORCYCLE LANES**

IBITOYE ADEOYE BILYAMIN

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**DOCTOR OF PHILOSOPHY
UNIVERSITI PUTRA MALAYSIA**

2007



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MOTORCYCLE LANES**

By

IBITOYE ADEOYE BILYAMIN

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
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Philosophy**

April 2007



DEDICATION

This work is entirely dedicated to my parents:

Alhaji Abdul-Ganiyu Akinade Ibitoye (a.k.a Hadji Kobomoje)

&

Mrs Bintu Diekola Ibitoye (a.k.a Eleha)



Abstract of thesis presented to the Senate of Universiti Putra Malaysia
in fulfilment of the requirement for the degree of Doctor of Philosophy

**DESIGN AND DEVELOPMENT OF GUARDRAIL FOR EXCLUSIVE
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IBITOYE ADEOYE BILYAMIN

April 2007

Chairman: Professor Ir. Radin Umar Radin Sohadi, PhD

Faculty: Engineering

The use of roadside barrier, especially W-beam guardrail has been demonstrated in various studies to have performed satisfactorily for protecting occupants of cars and trucks. However, its usage for motorcycle impact has been given little consideration. Thus, the safety of motorcyclists in relation to this barrier has become a major concern to road safety experts. Early studies have identified that motorcycle impact with this guardrail would result in severe injuries to the motorcyclists. However, relatively few studies have addressed the safety implication of this guardrail on motorcyclists. Presently, no studies have been reported to have specifically designed alternative guardrail for protecting motorcyclists especially along exclusive motorcycle lanes.

In view of this problem, this study focuses on the design and development of safer guardrail system that can replace the existing W-beam guardrail being used along exclusive motorcycle lanes, as exists in Malaysia. This design required use

of computer modelling and simulation as main tool and the conduct of a physical crash test to validate the baseline simulation model. Furthermore, the input parameters for the validated model were used for subsequent simulation of motorcycle crash on guardrail with 18 impact conditions. Results of this simulation were used to establish the design criteria. Based on the established design criteria alternative models were developed on the basis of achieving the design target; mainly to reduce potential injury risks to rider. The alternative models were combined to form 24 alternative models that were optimized in order to select the best model for the new guardrail design.

The new guardrail design consists of metal plate (grade 13 steel) of 2.28 mm thick, wider and continuous surface that has a high degree of flexibility that enables soft redirection of the rider. It is also comparable to the existing guardrail in ease of construction and installation and can have a potential to utilize economical end-treatment techniques. The effectiveness of the new design was evaluated using the same computer simulation program – MADYMO. The outcome demonstrated that severity of head injury risk can be reduced significantly if impact of head to the ground can be prevented. The high flexibility of the new guardrail prevents the rider from having head impact with ground. Thus, the results show that HIC and head acceleration values could be reduced by 96% and 91% respectively for a typical crash scenario of 48km/h impact speed on the guardrail orientated at 45 degree and 4m post spacing.

The major conclusions of the study are that modification of the configuration and material of the existing guardrail can significantly reduce potential injury risks to

motorcyclists and that the new guardrail is safer to replace the existing guardrail along exclusive motorcycle lanes.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**REKABENTUK DAN PEMBANGUNAN REL KAWALAN UNTUK LORONG
MOTORSIKAL EKSKLUSIF**

By

IBITOYE ADEOYE BILYAMIN

April 2007

Pengerusi: Professor Ir. Radin Umar Radin Sohadi, PhD

Fakulti: Kejuruteraan

Penggunaan rel keselamatan W-beam telah dibuktikan dalam pelbagai kajian dimana ia menepati tahap kepuasan bagi melindungi pengguna kereta dan juga trak. Walau bagaimanapun, penggunaan perlanggaran motorsikal kurang diberi perhatian di mana akhirnya ianya menjadi tumpuan utama kepada pakar keselamatan jalanraya. Kajian terdahulu telah mengenalpasti perlanggaran motorsikal dengan rel kawalan ini membawa kecederaan serius kepada penunggang motorsikal. Walau bagaimanapun, hanya sedikit kajian dijalankan yang telah meneliti implikasi keselamatan rel kawalan terhadap penunggang motorsikal. Sehingga kini, tiada kajian yang dilaporkan khusus merekabentuk alternatif rel kawalan bagi melindungi penunggang motorsikal terutamanya di sepanjang lorong-lorong motorsikal eksklusif. Bagi menangani masalah ini, kajian ini tertumpu kepada merekabentuk dan membangunkan sistem rel kawalan baharu yang lebih selamat bagi menggantikan penggunaan rel kawalan w-beam yang digunakan di sepanjang lorong-lorong motorsikal eksklusif yang terdapat di Malaysia. Rekabentuk ini memerlukan penggunaan model dan simulasi



berkomputer sebagai peralatan utama dan juga ujian perlanggaran fizikal bagi pengesahan garisan asas model simulasi. Sehubungan dengan itu, pelbagai parameter input digunakan untuk mengesahkan simulasi seterusnya iaitu perlanggaran motorsikal pada rel kawalan dengan 18 keadaan impak yang berbeza. Keputusan daripada simulasi ini digunakan untuk mendirikan kriteria rekabentuk. Berdasarkan kriteria rekabentuk tersebut, model alternatif dibangunkan berasaskan pencapaian sasaran rekabentuk iaitu untuk mengurangkan potensi risiko kecederaan kepada penunggang motorsikal. Model alternatif digabungkan untuk membentuk 24 model alternatif yang dioptimumkan bagi memilih model bagi rel kawalan baharu.

Rekabentuk rel kawalan baharu terdiri daripada kepingan logam (keluli gred 13) dengan ketebalan 2.28 mm, lebih lebar dengan permukaan sekata yang mempunyai darjah keanjalan yang tinggi membolehkan pertukaran haluan yang lebih lembut kepada penunggang motorsikal. Pembinaan dan pemasangan yang lebih mudah berbanding dengan rel kawalan sedia ada dan ia juga berpotensi untuk kegunaan teknik economical end-treatment. Tahap keberkesanan rekabentuk baharu ini telah dinilai dengan menggunakan program simulasi computer – MADYMO. Hasil kajian ini menunjukkan risiko kecederaan parah pada kepala dapat dikurangkan secara signifikan jika impak kepala terhadap permukaan jalan raya dapat dielakkan. Tahap keanjalan yang tinggi pada sistem rel kawalan baharu menghalang penunggang motorsikal mendapat impak kepala terhadap permukaan jalan raya. Ini menunjukkan nilai kriteria kecederaan piawai pada kepala (HIC) dan nilai pecutan kepala dapat dikurangkan kepada tahap minimum iaitu sebanyak 96% dan 91% bagi senario pelanggaran biasa iaitu pada

kelajuan impak 48km/j terhadap rel kawalan yang berorientasikan 45 darjah dan 4m jarak diantara tiang.

Kesimpulan utama kajian ini adalah pengubahsuaian terhadap konfigurasi dan penggunaan bahan pada rel kawalan sedia ada boleh secara signifikannya mengurangkan potensi risiko kecederaan terhadap penunggang motorsikal dan rel kawalan baharu ini adalah alternatif keselamatan terhadap penggunaan rel kawalan sedia ada yang digunakan di sepanjang lorong-lorong motorsikal eksklusif.

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I certify that an Examination Committee met on 19 April 2007 to conduct the final examination of Ibitoye Adeoye Biliyamin on his Doctor of Philosophy thesis entitled "Design and Development of Roadside Safety Barrier (Guardrail) for Exclusive Motorcycle Lane" in accordance with Unversiti Pertanian Malaysia (Higher Degree) Act 1980 and Unversiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Ir. Mohd. Razali Abdul Kadir, PhD

Associate Professor
Department of Civil Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Ir. Jamaloddi Noorzaei, PhD

Associate Professor
Department of Civil Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Sulistyo Arintono, PhD

Lecturer
Department of Civil Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Shaker A. Meguid, PhD

Professor
School of Mechanical and Aerospace Engineering
Nayang Technological University
Singapore
(Independent Examiner)

HASANAH MOHD. GHAZALI, PhD

Professor / Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

Ir. Radin Umar Radin Sohadi, PhD

Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Hamouda Abdel Magid, PhD

Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Wong Shaw Voon, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

AINI IDERIS, PhD

Professor / Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 17 June 2007

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been acknowledged. I also declare that it has not been previously or concurrently submitted for any degree at UPM or other institutions.

IBITOYE ADEOYE BILYAMIN

Date:

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