DESIGN AND DEVELOPMENT OF GUARDRAIL FOR EXCLUSIVE MOTORCYCLE LANES

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DESIGN AND DEVELOPMENT OF GUARDRAIL FOR EXCLUSIVE MOTORCYCLE LANES

By

IBITOYE ADEOYE BILIYAMIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of 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)
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 BILIYAMIN

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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IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

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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 Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti 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:

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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 BILIYAMIN

Date:
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEDICATION</td>
<td>ii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>vi</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>ix</td>
</tr>
<tr>
<td>APPROVAL</td>
<td>xiii</td>
</tr>
<tr>
<td>DECLARATION</td>
<td>xv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xix</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xxi</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>xxiv</td>
</tr>
</tbody>
</table>

## CHAPTER

### I INTRODUCTION

- Background of the Study: 1
- Review of Exclusive Motorcycle Lanes in Malaysia:
  - Motorcycle Crashes on Guardrail in Malaysia: 4
  - Motorcycle Crashes in Some Developed Countries: 7
- Overview of Guardrail System: 8
- The Need for the Study: 11
- Problem Statement: 12
- Objective of the Study: 16
- Scope and Limitation of Study: 16
- Assumptions and Limitations: 18
- Thesis Layout: 19

### II LITERATURE REVIEW

- Introduction: 21
- Crash Barrier Types and their Safety Risks: 22
  - Rigid Barrier: 22
  - Semi Rigid Barrier: 24
  - Flexible Barrier: 27
- Nature, Number and Severity of Motorcyclist Crashes: 29
- Injury Risks to Motorcyclists: 35
- Impact Biomechanics: 39
  - Mechanism of Injury: 39
  - Biomechanical Responses of Body Tissues: 41
  - Human Tolerance to Impact/Injury: 44
  - Injury Assessment Tools: 50
- Existing Efforts and Strategies for Protecting Motorcyclists: 51
  - Reducing the Impact Severity: 51
  - Preventing contact with barrier posts: 55
- Review of Design Approaches and Guidelines: 67
  - Physical Crash Testing: 67
  - Computer Modelling and Simulation Techniques: 69
  - Component Testing: 82
III DESIGN METHODOLOGY

Introduction 107
Simulation Modelling Process 110
  Road Surface 111
  Guardrail Model 111
  Motorcycle Model 112
  Crash Dummy Model 119
Contact Interaction 120
Physical Crash Test 122
  Test Facilities 122
  Site Layout 126
  Crash Test Set Up 127
Model Validation 130
Establishing Design Criteria 132
Development and Optimization of Alternative Guardrail Design 133
Summary 136

IV SIMULATION OF RIDER’S KINEMATICS AND MODEL VALIDATION

Introduction 137
Problem Definition 138
  Reference Space 138
  Guardrail Structure 138
  Forces Acting on Guardrail 139
  Displacement Constraint 141
Physical Crash test 141
Baseline Crash Simulation 142
Model Validation 143
Subsequent Crash Simulation Analysis 147
  Rider’s Kinematics 147
  Potential Injury Risks to Rider 163
Verification of Simulation Results 169
  Kinematics of Rider 170
  Time history curves for dummy head displacement 170
  Time history curves for guardrail node displacement 173
Established Criteria for Design of Guardrail 175
Summary 178

V DESIGN AND DEVELOPMENT OF NEW GUARDRAIL SYSTEM 179
Introduction 179
Developed Alternative Designs 180
Optimization of Alternative Models 181
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>The Reported First Collision Type In Motorcycle Crashes along Exclusive Motorcycle Lanes</td>
<td>6</td>
</tr>
<tr>
<td>1.2</td>
<td>Fatality Caused by Roadside Objects on Exclusive Motorcycle Lanes along Federal Highway F0002 and Sha Alam Expressway from 1998 to 2001</td>
<td>7</td>
</tr>
<tr>
<td>1.3</td>
<td>Effect of Guardrail Features on Motorcycle Accident</td>
<td>15</td>
</tr>
<tr>
<td>2.1</td>
<td>Type of roadside objects involved in motorcycle crashes along Exclusive motorcycle lanes in Malaysia</td>
<td>31</td>
</tr>
<tr>
<td>2.2</td>
<td>Number and Proportion of Motorcyclists in Types of Casualty Crashes in Bavaria with AIS2+ injuries to Specified Body Regions</td>
<td>37</td>
</tr>
<tr>
<td>2.3</td>
<td>Previously used Physical Crash Testing Configurations</td>
<td>67</td>
</tr>
<tr>
<td>2.4</td>
<td>Typical Energy Absorption</td>
<td>91</td>
</tr>
<tr>
<td>2.5</td>
<td>Typical Stiffness of Composites</td>
<td>91</td>
</tr>
<tr>
<td>2.6</td>
<td>Mechanical Properties of a Single Lamina</td>
<td>92</td>
</tr>
<tr>
<td>2.7</td>
<td>Summary and Justification of Chosen Investigated Problems</td>
<td>103</td>
</tr>
<tr>
<td>3.1</td>
<td>Selection of Simulation Software Package</td>
<td>110</td>
</tr>
<tr>
<td>3.2</td>
<td>Motorcycle Description</td>
<td>115</td>
</tr>
<tr>
<td>3.3</td>
<td>Scaled Hybrid III Dummy</td>
<td>119</td>
</tr>
<tr>
<td>3.4</td>
<td>Impact Conditions for Crash Simulation</td>
<td>132</td>
</tr>
<tr>
<td>3.5</td>
<td>Matrix of Proposed Alternatives</td>
<td>134</td>
</tr>
<tr>
<td>3.6</td>
<td>Experimental Design for Optimization of Design Target</td>
<td>135</td>
</tr>
<tr>
<td>4.1</td>
<td>Description of Existing Guardrail Model</td>
<td>139</td>
</tr>
<tr>
<td>4.2</td>
<td>Guardrail Material Properties</td>
<td>140</td>
</tr>
<tr>
<td>4.3</td>
<td>Correlation between Crash Test and Simulation of Head Displacement</td>
<td>146</td>
</tr>
<tr>
<td>4.4</td>
<td>Potential Injury Risks at impact angle $15^\circ$ for different speeds</td>
<td>164</td>
</tr>
</tbody>
</table>
4.5 Potential Injury Risks at impact angle 30° for different speeds 165
4.6 Potential Injury Risks at impact angle 45° for different speeds 165
4.7 Head Injury Severity related to Impact angle and Impact speed 176
5.1 Description of Design Concept and Targets 180
5.2 First Stage Design Optimization Output 182
5.3 Second Stage Design Optimization Output 183
5.4 Final Output of Design Optimization 184
5.5 Matrix Evaluation of Alternative Guardrail Designs 186
5.6 Geometric Specification of New and Existing Guardrail 189
5.7 Comparing Potential Injury Risks between Existing Guardrail and New Guardrail Design 191
5.8 Advantages of New Design over the Existing Design 195
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>2.10</td>
<td></td>
</tr>
<tr>
<td>2.11</td>
<td></td>
</tr>
<tr>
<td>2.12</td>
<td></td>
</tr>
<tr>
<td>2.13</td>
<td></td>
</tr>
<tr>
<td>2.14</td>
<td></td>
</tr>
<tr>
<td>2.15</td>
<td></td>
</tr>
<tr>
<td>2.16</td>
<td></td>
</tr>
<tr>
<td>2.17</td>
<td></td>
</tr>
<tr>
<td>2.18</td>
<td></td>
</tr>
</tbody>
</table>

1.1 Typical View of On-Grade - Segregated Exclusive Motorcycle Lane in Malaysia
1.2 Typical View of Grade Separated - Segregated Exclusive Motorcycle Lane in Malaysia
1.3 Number of Motorcycle Crashes Reported in Malaysia
2.1 Photograph and Profile of New Jersey barrier
2.2 Typical W-Beam Guardrail Systems
2.3 Cross section of Typical Wire Rope Safety Fence
2.4 Photograph of Typical Wire Rope Safety Fence
2.5 Illustration of Motorcycle impact into crash barrier
2.6 Proportion of Motorcyclist with Head or Neck injuries from impacts with a Class of Objects in each injury Severity Category
2.7 Blunt Impact of Head Accelerates the Skull
2.8 Neck Responses due to Downward Impact of Head
2.9 Human Tolerance Curve
2.10 The Wayne State Tolerance Curve
2.11 Schematic drawing of IPE-100 and Sigma post cross section
2.12 Fitting of additional W-Beam
2.13 Profile and Photograph of Impact attenuator
2.14 Photograph of Guardrail with Secondary Rail
2.15 Photograph and Schematic drawing of “Ecraan Motard” fitted to an existing guardrail
2.16 Photograph and Schematic drawing of “Plasti-rail” fitted to an existing guardrail
2.17 Photograph and Schematic drawing of the “Motorail”
2.18 Photograph and Schematic drawing of the “Mototub”