UNIVERSITI PUTRA MALAYSIA

DESIGN OF MOTORCYCLE SAFETY HELMET FOR CHILDREN IN MALAYSIA

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By

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: Radin Umar Radin Sohadi, Ph.D.

Faculty: Engineering

The first part of the study is undertaken to investigate the need for a motorcycle safety helmet for children. From the field observations and interviews conducted, it was found that the current situation warrants the need for a motorcycle safety helmet for children to be developed. Motorcycle safety helmet, as an injury control device is used to curb the high fatality rate associated with head injuries among motorcycle users.

In addition, a field study was conducted to investigate the design parameters of the helmet. A head size of 570mm in circumference was selected based on the size that fits the maximum number of users and the availability of the test head form sizes. It was found that a lighter helmet is generally preferred from the comfort viewpoint.

The second part of the study involves the design of the motorcycle safety helmet for children. A finite element model of the children motorcycle safety helmet for impact

test was developed using Hypermesh, a pre-processor. LS-DYNA, a finite element code was used to simulate the impact response of the helmet. The model was validated using an indirect inference approach. The results clearly indicate that the model correlated well with the experimental results from literatures. A simple parametric study was carried out to investigate the effect of varying thicknesses of the Acrynonitrile Butadiene Styrene (ABS) shell and the Expanded Polystyrene (EPS) foam It was found that the typical thicknesses of the shell and foam provide the best compromise between the shock absorbing performance and the design constraints. None of the eight impacts simulated in accordance to the MS 1 1996 type test resulted in an acceleration exceeding the permissible level of 300 g From the simulations, the helmet impact deformation mechanisms were discussed. It is recommended that future research to be carried out to further improve the design of the motorcycle safety helmet and to study the possible ventilation systems In addition, it is suggested that a more stringent form of verification to be undertaken to validate the FE model of the helmet.

Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

REKABENTUK TOPI KELEDAR KANAK-KANAK DI MALAYSIA

Oleh

ONG WEI YANG

Julai 2001

Pengerusi : Radin Umar Radin Sohadi, Ph.D.

Fakulti : Kejuruteraan

Bahagian pertama kajian ini adalah untuk menilai keperluan bagi rekabentuk topi keledar motosikal khas untuk kanak-kanak Hasil daripada pemerhatian serta temubual yang dijalankan, didapati keperluan tersebut adalah mendesak kerana tiada topi keledar yang sesuai direka khas untuk kanak-kanak. Topi keledar motosikal digunakan untuk mengurangkan kadar kematian yang tinggi akibat kecederaan pada bahagian kepala di kalangan pengguna motosikal khususnya kanak-kanak

Di samping itu, kajian ini juga bertujuan untuk menyiasat pembolehubah-pembolehubah rekabentuk topi keledar motosikal kanak-kanak. Ukur lilit saiz kepala bersamaan dengan 570 mm dipilih berdasarkan saiz yang dapat dimanfaatkan oleh majoriti kanak-kanak tempatan dan kesesuaian dengan saiz 'dummy' ujian Selain daripada itu, kajian juga mendapati bahawa topi keledar yang lebih ringan adalah lebih digemari dari segi keselesaan

Bahagian kedua kajian melibatkan rekabentuk topi keledar motosikal kanak-kanak. Hypermesh v3.0.1 digunakan sebagai pra-prosesor untuk membina model unsur terhingga bagi ujian impak topi keledar motosikal kanak-kanak. Simulasi impak topi keledar pula dijalankan dengan menggunakan LS-DYNA v940 sebagai prosesor. Keputusan simulasi yang diperolehi menunjukkan korelasi yang baik dengan keputusan eksperimen daripada literatur. Selain daripada itu, satu kajian parametrik ringkas juga telah dijalankan untuk mengkaji kesan perubahan ketebalan pelindung ABS dan lapisan penyerap hentakan EPS. Hasil daripada kajian menunjukkan bahawa kompromi terbaik antara pretasi serapan hentakan dan had-had rekabentuk dapat dicapai melalui ketebalan-ketebalan tipikal EPS dan ABS. Di samping itu, dapat ditunjukkan bahawa kelapan-lapan simulasi impak berasaskan ujian jenis MS 1: 1996 menghasilkan pecutan tidak melebihi paras 300 g seperti yang dibenarkan dalam piawai kebangsaan. Mekanisma deformasi juga turut dibincangkan dalam kajian ini berdasarkan simulasi komputer yang diperolehi. Adalah dicadangkan bahawa kajian pada masa akan datang dijalankan untuk menyelidik rekabentuk topi keledar motosikal yang lebih baik dan mengkaji jenis sistem-sistem ventilasi yang dapat digunakan. Selain daripada itu, adalah dicadangkan bahawa satu kaedah yang lebih mantap dijalankan untuk membanding dan menentusahkan keputusan simulasi dengan keputusan ujian.

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science.

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LIST OF ABBREVIATIONS

ABS	Acrynonitrile Butadiene Styrene
C.G.	Centre of Gravity
CI	Confidence Interval
CL	Confidence Level
EPS	Expanded Polystyrene
FE	Finite Element
FEA	Finite Element Analysis
FEMB	Finite Element Model Builder
FEM	Finite Element Model
GRP	Glass Reinforced Plastics
HIC	Head Injury Criterion
MAAP	Microcomputer Accident Analysis Package
MRI	Magnetic Resonance Imaging
MS	Malaysian Standard
ms	millisecond
PC	Personal Computer
PDRM	Polis DiRaja Malaysia
RAM	Random Access Memory
UPM	Universiti Putra Malaysia

CHAPTER I

INTRODUCTION

Background of the Study

A strong population and economic growth experienced during the past two decades has seen a parallel growth in traffic in Malaysia. Between 1975 and 1997, the population increased 108% from 10,438,137 to 21,665,600 (PDRM, 1997). This is accompanied by a growth in traffic demand. Between 1975 and 1997, the total road length has grown from 12,043 to 63,382 km, a five –fold increase. Within the same period, the number of registered vehicles increased six –fold from 1,267,119 to 8,550,469. Consequently, vehicle ownerships increase from 8.23 people per vehicle to 2.53 people per vehicle.

As a result of rapid traffic growth, the total number of road crash has increased 447% from 48,233 to 215,632 between 1975 and 1997. In 1996, injury was a third leading cause of death and hospitalization. A study on the epidemiology of injury in Malaysia showed that road crash related injury accounted for 42% of the total reported injury during the study period (MOH, 1997). In 1997, adolescents (16 -20 year-old) and young adults (21-25 year-old) formed 43.1% of the total injury casualty on the road (PDRM, 1997). It is a main cause of loss of potential years of life in adolescents and young adults.

Motorcycles form a large portion (50.6%) of the total traffic composition in Malaysia (PDRM, 1997). Motorcycle being a convenient and cheap mode of transportation, is used as a major mode of personal transport mainly by the lower income community. The number of motorcycle ownerships has increased 194% over a decade from 2,236,167 to 4,328,997 between 1984 and 1997.

As the result, the number of road crashes involving motorcycle increased 262% from 30,611 to 80,100 within the same period. Due to the increase in motorcycle crashes, the number of fatalities involving motorcycle has also increased from 209 in 1974 to 3,760 (motorcyclists and pillion riders) in 1997. Fatalities involving motorcyclists and pillion riders form a major portion of the total road fatalities each year. In addition, there has been a steady increase in percentage (on the average 2.3% annually) of total fatalities involving motorcyclists and pillion riders from 41.7% to 59.9% between 1988 and 1997 with the exception in 1997 where it decreased by 0.2%. The number of cases of motorcycle crash related injuries has also increased from 3,460 to 37,843, a 1094% increase between 1974 and 1997.

In view of the increasing number of road fatalities, a Cabinet Committee on Road Safety was set up in 1990 with the objective of reducing traffic fatalities by 30% by the year 2000. An extensive National Road Safety Plan was formulated the following year covering areas such as behavioural modification of road users, safety research, road engineering, vehicle safety, and medical treatment and safety administration.

In view of the National Safety Plan, the Ministry of Transportation has appointed the Road Safety Research Centre, Faculty of Engineering of UPM as a consultant to carry out research on motorcycle safety in Malaysia Based on the projection of the fatality model (Radin et al., 1998), 9,127 road users would be killed by the year 2000 (Figure 1 1)

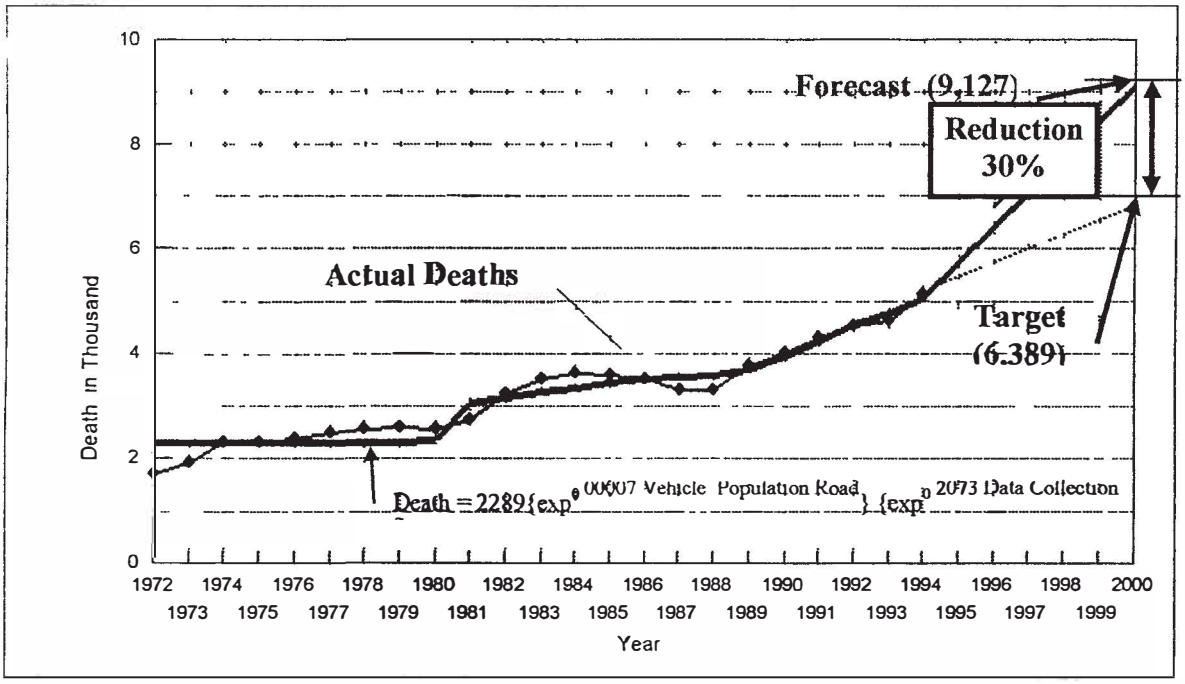

Figure 1 1 Fatality Model Projection for Year 2000 (Radin et al., 1998)

Due to the absence of passive safety features in a motorcycle, the motorcyclist and the pillion rider risked higher injury severity in the event of collision It is estimated that the risk of injury of the motorcyclist and the pillion passenger are ten to thirty times greater than car passengers

In 1997, head injuries accounted for 22.3% of the 24,908 reported cases of casualties injuries due to road crashes (PDRM, 1997). In the same year, there were 3,158 fatalities due to head injuries, representing 52.7% of the total fatalities. Head injury is the leading cause of death among motorcyclists and their pillion riders with 1,639 and 252 deaths respectively.

As the motorcycle does not provide adequate safety passive features such as an impact-absorbing zone, the only possible protection are limited to a safety helmet and appropriate protective clothing. An approved motorcycle safety helmet is able to protect its wearer from head injuries due to impacts of different severities on various objects. The outer shell of the helmet is usually made of polycarbonate, fibre glass, glass reinforced plastics (GRP) or Acrynonitrile Butadiene Styrene (ABS). ABS is used as it has a high resistance to penetration. In the event of collision, the ABS shell absorbed 30-40% of the total impact energy (Mills et al., 1991). Expanded polystyrene foam is used as a shock-absorbing component in a motorcycle safety helmet. It absorbs almost 95% of the total impact energy (Mills et al., 1991). A comfort liner is used between the inside of the polystyrene foam and the head. The components of a typical motorcycle safety helmet are shown in Figure 1.2.

Although helmet law has been introduced in the 70s and saw approximately 30% reduction in fatalities (Supramaniam et al., 1984), young children often ride with unqualified helmets or without any protective head gear.