UNIVERSITI PUTRA MALAYSIA

MOTORCYCLE - STOPPING SIGHT DISTANCE MODEL FOR GEOMETRIC DESIGN OF EXCLUSIVE MOTORCYCLE LANES

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FK 2011 50
MOTORCYCLE - STOPPING SIGHT DISTANCE MODEL FOR GEOMETRIC DESIGN OF EXCLUSIVE MOTORCYCLE LANES

By

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

July 2011
DEDICATION

To my wife, Mahdieh and my daughter, Delara

and

All those working to enhance the safety of transportation system, and saving people’s life.
MOTORCYCLE - STOPPING SIGHT DISTANCE MODEL FOR GEOMETRIC DESIGN OF EXCLUSIVE MOTORCYCLE LANES

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July 2011

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In developing ASEAN countries, motorcycle is a popular transport mode because it is cheap and provides flexible door-to-door mobility. But motorcyclists are also highly involved in road crashes. Separating motorcycles from other vehicles in traffic by providing motorcycle lanes is a good engineering measure to improve safety of motorcyclists. In designing the motorcycle lanes, designing of geometrical elements such as the horizontal and vertical curve lengths to provide of adequate stopping sight distance at every point along the roadway are essential. There are few studies on motorcycle characteristics, but none of them addressed the safe stopping sight distance in the geometric design of motorcycle lanes.

Stopping sight distance is calculated using basic principles of physics and relationships among the various design parameters. The majority parameters effects on stopping sight distance are: (i) vehicle characteristics, (ii) driver perception
response time, and (iii) driver deceleration rate. This research consists of four
different field studies that were undertaken under controlled testing environments
for the different aspects that make up the components of the motorcycle stopping
sight distance. (i) Motorcycle characteristics, which in study 1 collected real world
data to construct a cumulative distribution of rider eye, motorcycle headlight,
taillight and motorcyclist head heights as determined by a current motorcycle fleet
in Malaysia. Characteristics of the motorcycles observed along the existing
exclusive motorcycle lanes in Selangor state of Malaysia were transcribed from a
.camcorder, using reference dimension. (ii) Motorcyclist Braking Performance,
which consisted of three different field studies to obtain riders perception response
time, riders deceleration ratio (braking distance). Study 2, tested a rider’s simple
perception response time. In this study participants sat on their motorcycles exactly
the same way they do while riding and then they awaited activation of the taillight
passenger car (parked) in front of them. Perception response times of the
motorcyclists were transcribed from camcorder when the riders hit the brakes as
quickly as possible following the activation of the car brake light. Study 3 and 4
evaluated rider braking performance including rider perception response time,
braking performance and deceleration to an expected and unexpected object on the
road. In this study 3, participants rode motorcycle and released the accelerator and
applied brake as quickly as possible following activation of a light by the roadside.
Study 4, measured rider braking performance when unalerted riders were
confronted with the need to stop for an unexpected object that suddenly appeared in
the roadway.
The motorcycle characteristic study found that all 525 motorcyclist eye heights are higher than the AASHTO 2004 design value of 1,080 mm. It is noted that the 5\textsuperscript{th} percentile driver eye level height is 1,350 mm while the 10\textsuperscript{th} percentile motorcyclist eye level is 1,367 mm. The 5\textsuperscript{th} and 10\textsuperscript{th} percentile motorcycle headlight heights are 800 mm and 880 mm respectively and the 5\textsuperscript{th} and 10\textsuperscript{th} percentile motorcycle taillight heights are 625 mm and 634 mm respectively.

The results of braking performance studies for rider simple perception response time show that the mean and the standard deviation of the motorcycle simple PRT are 0.44 sec and 0.11 sec respectively. The mean perception response time to expected and unexpected object scenario is 0.71 sec and 1.25 sec respectively. The 95\textsuperscript{th} percentiles unexpected object perception response time was 2.12 sec. The findings from these studies indicated that most riders are capable of responding to an unexpected object in the roadway in 2.5 sec or less.

The results of braking performance studies for rider deceleration and braking distance show that the 90 percent of all riders chose deceleration of at least $3.3 \text{ m/s}^2$ on dry pavements. The study found that most riders chose decelerations that are greater than $2.75 \text{ m/s}^2$. These decelerations are within riders’ capabilities to stay within their direction and maintain steering control during the braking maneuver on wet surfaces.

Overall, this research proposed a motorcycle stopping sight distance model based on motorcycle characteristics, motorcyclist capabilities and performance in
response to an expected and unexpected object along the exclusive motorcycle lanes. Results of this research are not only useful for geometric design of exclusive motorcycle lanes but can be used for geometric design of roads in countries with high motorcycle volumes.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

MODEL JARAK PENGLIHATAN UNTUK MEMBERHENTIKAN MOTORSIKAL BAGI REKABENTUK GEOMETRI LALUAN MOTORSIKAL EKSKLUSIF

Oleh

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Di kalangan penduduk negara-negara ASEAN yang sedang membangun, motosikal merupakan pilihan pengangkutan yang amat popular kerana ianya murah dan menyediakan mobiliti yang amat fleksibel. Namun begitu, penunggang motosikal sering kali terlibat dengan kemalangan jalan raya pada kadar yang tinggi amat membimbangkan. Justeru itu, penyediaan lorong motosikal untuk mengasingkan motosikal daripada berkongsi trafik dengan kenderaan lain merupakan satu kaedah kejuruteraan yang baik untuk meningkatkan keselamatan penunggang motosikal. Unsur- unsur geometri seperti panjang lengkung mengufuk dan menegak adalah penting dan harus dititikberatkan semasa perancangan rekabentuk laluan motosikal. Ini dapat menyediakan jarak penglihatan yang mencukupi untuk berhenti pada setiap titik di sepanjang laluan motosikal tersebut. Walaupun terdapat beberapa kajian lepas mengenai ciri-ciri motosikal, kajian-kajian tersebut tidak
mengutamakan jarak penglihatan untuk berhenti yang selamat dalam rekabentuk geometrik lorong motosikal.

Jarak penglihatan untuk berhenti dikira dengan menggunakan prinsip asas fizik dan perhubungan antara pelbagai parameter rekabentuk. Kebanyakan parameter yang memberi kesan kepada jarak penglihatan untuk berhenti adalah: (i) ciri-ciri kenderaan, (ii) masa tindak balas tanggapan pemandu, (iii) kadar nyahpecutan pemandu. Kajian ini meliputi empat bidang penyelidikan yang berlainan dan semua ujian dilakukan di dalam persekitaran yang terkawal agar semua aspek berbeza yang membentuk komponen-komponen jarak penglihatan untuk memberhentikan motosikal dipenuhi. (i) Kajian pertama mengenai ciri-ciri motosikal, mengumpul data masa benar (real time) seperti ketinggian mata penunggang, ketinggian lampu depan motosikal, ketinggian lampu belakang dan ketinggian kepala penunggang motosikal untuk membina satu taburan terkumpul seperti yang ditetapkan oleh armada motosikal di Malaysia. Motosikal-motosikal di sepanjang lorong motosikal eksklusif yang wujud di negeri Selangor, Malaysia telah diperhatikan melalui kamkorder yang disalin menggunakan dimensi rujukan untuk mendapatkan ciri-ciri motosikal. (ii) Prestasi membrek penunggang motorsikal yang mengandungi tiga sub-kajian iaitu memperoleh masa tindakbalas tanggapan penunggang, nisbah nyahpecutan penunggang (jarak pembrekan). Kajian 2, menguji masa tindakbalas tanggapan mudah seorang penunggang. Di dalam kajian ini, para peserta duduk di atas motosikal mereka (diparkir) sepertimana mereka duduk semasa menunggang motosikal dan menunggu pengaktifan lampu brek kereta (diparkir) di depan

Penemuan kajian ciri-ciri motosikal mendapati di kalangan 525 penunggang motosikal, kesemuanya memiliki ketinggian mata melebihi ketinggian daripada AASHTO 2004 dengan nilai rekabentuk, 1080 mm. Aras mata penunggang motosikal pada persentil kelima dicatatkan pada ketinggian 1350 mm manakala aras mata pada persentil ke-10 ialah 1367 mm. Lampu depan motosikal pada persentil kelima dan kesepuluh masing-masing mencatatkan ketinggian 800 mm dan 880 mm manakala persentil kelima dan kesepuluh ketinggian lampu belakang motosikal adalah masing-masing 625 mm dan 634 mm.

Keputusan yang diperolehi daripada kajian prestasi membrek untuk masa tindak balas tanggapan penunggang mudah menunjukkan min dan sisihan piawai untuk masa tindak balas tanggapan penunggang mudah ialah masing-masing 0.44 saat dan
0.11 saat. Min masa tindak balas tanggapan untuk objek dijangka dan tidak dijangka masing-masing ialah 0.71 saat dan 1.25 saat. Persentil ke-95 bagi masa tindak balas tanggapan objek tidak diduga ialah 2.72 saat. Penemuan dari kajian ini mendapati kebanyakan penunggang mampu bergerak balas kepada objek tidak diduga di atas laluan jalan dalam 2.5 saat atau kurang daripadanya.

Keputusan kajian prestasi membrek untuk nyahpecutan penunggang dan jarak membreka menunjukkan 90 peratus penunggang memilih nyahpecutan sekurang-kurangnya 3.3 m/s² di atas jalan kering. Penemuan daripada kajian ini pula mendapati kebanyakan penunggang memilih nyahpecutan yang lebih besar daripada 2.75 m/s². Nyahpecutan ini masih dalam keupayaan penunggang untuk memastikan halatuju mereka dan mengekalkan taktik kawalan penunggangan semasa membrek pada permukaan jalan yang basah.

Secara keseluruhannya, penyelidikan ini mencadangkan model jarak penglihatan untuk memberhentikan motosikal dengan selamat berdasarkan kepada ciri-ciri motosikal, keupayaan penunggang motosikal dan prestasi tindakbalas bagi objek dijangka dan tidak dijangka di sepanjang laluan motosikal eksklusif. Keputusan penyelidikan ini bukan sahaja berguna untuk rekabentuk geometrik lorong motosikal eksklusif tetapi ia juga boleh digunakan sebagai merekabentuk jalan-jalan secara geometrik di negara-negara yang mempunyai kepadatan penunggang motosikal yang tinggi.
ACKNOWLEDGEMENTS

First of all, I would like to express my gratitude to Allah (S.W.T.) for providing me with the strength, health, courage and intellect to complete my research work.

I would like to deeply acknowledge and highly appreciate my dear supervisor, doctor Hussain Hamid, Lovell for his invaluable advice, time and support to me at every juncture of my research work and to successfully complete this dissertation. His extraordinary guidance and support motivated and encouraged me to work hard each day to accomplish the goals of my research. I would also like to express my sincere thanks to my dissertation committee members for their invaluable advice and interest in my dissertation.

I would like to gratefully acknowledge the enthusiastic guidance of Dr. Law Teik Hua, whose suggestions, inspiration and encouragement motivated the realization of this thesis.

Sincere thanks to Feisal Bin Awang and his colleagues at Security Department of Universiti Putra Malaysia for providing safety during data collection of this study. Also thanks to the staff at the Department of Civil Engineering Universiti Putra Malaysia for their support and co-operation during my Ph.D study.

I would like to thank all my friends Ali Jahan, Sharam Arifar, Jafar Shabani, Sharyar Soroshyan, Kian Azari, Mohammadreza Vasighi and Hadi Yazdanshenas
for assisting me with data collection and for helping out with the experiments. Without their help this Thesis could not have been completed.

I deeply appreciate the unquantifiable contribution offered by my beloved wife Mahdieh for her daily support and reassurance. Her ability to comfort me through all my frustrations and always bring a smile to my face has helped me to see the positive side of every situation. Thanks, for her participation during data collection, compilation, organization and construction ideas towards the fulfillment of this study.

This acknowledgment is in complete without mentioning my daughter Delara for her extra patience for ignoring her in most cases during the study.

Lastly, a sincere thanks to my family without whose support this would not have been possible. I would like to express my heartfelt thanks and appreciation to my mother, brother and sister for their extra-ordinary support, love and encouragement.
APPROVAL

I certify that an Examination Committee has met on date of viva to conduct the final examination of Seyed Rasoul Davoodi on his Doctor of Philosophy thesis entitled "MOTORCYCLE STOPPING SIGHT DISTANCE MODEL USE IN EXCLUSIVE MOTORCYCLE LANES GEOMETRIC DESIGN" 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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DECLARATION

I hereby declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

SEYED RASOUL DAVOODI

Date: 26 July 2011
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