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Article

Effective Motorcycle Lane Configuration Thailand: A Case Study of Southern Thailand

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Abstract. Motorcycle lane has proved to be an effective engineering measure in reducing motorcycle crashes and fatalities. Its effectiveness stems from the fact that it helps mitigate the hazards of riding a motorcycle in a traffic stream, which have become a serious cause of death and injury in many countries. This research seeks to develop standardized configurations and widths for motorcycle lanes in Thailand. The optimum format for such a lane may be determined from the simulation of data relating to road accidents, traffic volumes and vehicle speeds. In practice, a range of initial lane widths were inputted into a traffic simulator program – in this case, the VISSIM 5.4 – whose output was analyzed to yield the relationship between MC volume, lane width and level of service (LOS). A pilot test was then performed on a stretch of actual road which had been installed with an MC lane of varying widths. Changes in vehicle speed were observed and employed to determine the relationship between lane width and the actual reduction in vehicle speed and the theoretical reduction in road accidents. Findings of the study point to an efficient lane width in the range of 2.0 to 3.0m – for the shared lane configuration. For any width outside the said range, the benefit of the MC Lane would be eroded either by the intrusion of larger vehicles, or by the constraining effect of too narrow a lane. The authors also recommends the preferred width for an Exclusive MC Lane which may range from 3.0 to 4.0m. The lane width of 3.0m is found to be the most effective in reducing the speed of all traversing vehicles, even when compared with the 2.5m or 3.5m widths. With the 3.0m option, the resulting reduction in speed can be as high as 17%; and reduction of accidents, up to 25%. In view of the aforementioned, the authors recommend configuring for the Shared Motorcycle Lane of 3.0m with 2 sublanes of 1.5m width, and for the Exclusive Motorcycle Lane 3.0 – 4.0m with 2 sublanes of 1.5 to 2.0m width.

Keywords: Motorcycle lane, lane width, motorcycle speed.

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1. Introduction

Road traffic accidents have become a problem of global proportions. Recent estimates by the World Health Organization put the worldwide road crash fatality rates at 1.24 million deaths per year, about 59% of which affecting people in the 15–44 age group; while the life of 50 million more is made difficult by serious injuries. The daily global average of number of road fatalities is 3,400. For countries with a low or medium GDP, including Thailand, the percentages of deaths by road crashes are as high as 90% of the global fatality; while the remaining 10% shared by the higher-income nations. About 50% of the global road deaths involved the vulnerable road users including MC riders, pedestrians and cyclists – at 23%, 22% and 5% respectively [1]. Southeast Asia is noted for its high ranking in road deaths when compared with those occurring in other regions. For Thailand, some 74% of road deaths involved MC users. Following Thailand are Cambodia, at 63%; Indonesia, at 61%; Malaysia, at 58% and Singapore, at 58% [2]. A global accident survey covering 193 countries by the Michigan University's Transport Research Institute, featuring a comparison of traffic-induced fatalities against those caused by illnesses, listed the average global crash-induced deaths at 18 per 100,000 people. Topping the list is Namibia with a ratio of 45 deaths per 100,000 population – far above the average. Thailand comes in a close second – at 44 deaths per 100,000; while Maldives has the lowest ratio of 2 per 100,000. The global average for fatalities from road crashes as a percentage of fatalities from other leading causes was found to be 2.1%. Nonetheless, Thailand's ratio is a whopping 5.1%, or more than doubling the global average. Road crash fatalities in Thailand are surpassing deaths caused by other diseases: the road deaths are higher than those caused by heart diseases (55.8% higher); or malignant cancer (42.1% higher); or brain hemorrhaging (40.6% higher) [3]. Malaysia has taken the initiatives to implement a range of measures designed to reduce road accidents and protect the MC riders; constructing MC lanes is a key measure. The MC lanes segregate the traffic of large vehicles from the MCs, and at the same time, help to improve the sight distance of the drivers of trucks and cars. The move has helped reduce accidents by 39%, and MC deaths by 83% [4]. Initiatives of this kind are being actively pursued in Thailand. The Road Safety Master Plan 2009 – 2012 by the Center for Road Safety, Department of Disaster Prevention and Reliefs, has set out strategies and guidelines for installing MC lanes on community roads and on routes where there is a high degree of mixing MCs with other vehicles.

This paper sets out the principles and methodology for developing suitable MC lane configurations. It is the author's hope that the paper will offer some insights for the establishment of MC lanes.

2. Literature Review

The authors conducted an exhaustive review of available literature on road safety in Thailand, and motorcycle (MC) speed and a selection of computer programs for local-area traffic simulation. Results of the review are summarized below.

One of the many challenges in Thailand road safety is the low safety records of inter-city travel with its high casualty rate as a consequence of roadside crashes, a study has shown that the situation could be improved by simply following the clear zone guideline more closely [5]. Safety at intersection is also a challenge, as MC riders often disobey traffic signals. The situation is made worst during construction to upgrade an at-grade intersection to grade separated junction, when casualties are increased [6]. On the issue of driving behavior, speed is probably the key challenge and the most-frequently cited factor contributing to motorcycle crashes. It has been found that in a traffic stream, MCs tend to have higher speeds than do cars at the beginning of movement after the green light, but in mid-stream MC speeds fall below those of cars. Along narrow streets MCs would have a higher speed [7]. Using laboratory experiments and roadside observation [8] it was concluded that motorcyclists would typically go for faster speeds than car drivers would; and that younger people generally travel faster than older road users [9]. A study of MC crashes in Europe by MAIDS team [10] found that the difference in the traveling speed of MCs relative to that of the surrounding traffic has a direct bearing on 66% of the crashes involving MCs. In traffic safety terms, pedestrians, cyclists, and riders of motorized two-wheelers and their passengers are collectively known as "vulnerable road users". According to [1] the proportion of road traffic deaths occurring to vulnerable road users is greater in low-income countries than that in high-income countries. Only 59 countries, covering 39% of the world's population (or 2.67 billion people), have imposed a measure of urban speed limit, which is typically 50 km/hr or less; and local authorities are allowed to further reduce such a limit. The positive effect of speed reduction has been the subject of intensive studies in Europe and the U.S. in recent decades.

Field evidence from such studies has verified that: a 5% cut in the mean traffic speed can contribute to a reduction in the number of fatal crashes by as much as 20% [11]; and a decrease of 1.0 km/hr of the same can result in a 3% decrease in the number of injury crashes (or a decrease of 4 to 5% for fatal crashes). By contrast, where the mean speed is raised by a mere 1.0 km/hr, the corresponding increases in injury crashes and fatal crashes are 3% and >4% respectively [12].

For Thailand, the idea of MC lane has been around for decades, although rigorous application of this road feature has yet to take hold. On 29 July 2000, the Thai Cabinet approved pilot tests for four MC lane configurations: 1) a one-way lane on the shoulder of the Chiang Mai-Mae Rim Highway, having a 2.0m width and being marked out with a white 0.1m edge line; 2) a lane between a car lane and the road shoulder — two instances of this were set up in Phuket and Lampang provinces; 3) a semi-exclusive MC lane in Tak province where it is positioned on a strip along the left of the road shoulder, and marked out with intermittent barriers; and 4) an exclusive MC Lane, the trial for which has not yet been attempted. Despite the insufficient local data on this road feature, the Office of Transport and Traffic Policy and Planning (OTP) has recommended guidelines for setting up MC lanes of varying capacities: For a lane with daily traffic up to 3,000 mc, the guidelines recommend a 2.0m lane for a one-way MC stream, to be positioned on a 3.0m wide road shoulder; for a daily traffic of 12,000 mc, the lane is to be exclusive for a one-way traverse and separated from other traffic lanes by green strips. OTP also suggests the construction of low clearance underpasses at intervals of 3 – 5km for right turns [13]. By contrast, Malaysia sets their MC lane width from 2.5 – 3.5m, flanked by a road shoulder of 1 – 2m wide, and good for MC speeds up to 70 km/hr. According to the study by Radin et.al [14] on the relationship between MC flow rate, density, level of service and lane width, it was found that for an MC lane of 2.5–3.5m width at level of service E, the lane is able to take up 5,300–7,750 mc/hr/ln [15]. In Taiwan, where Intelligent Transportation System has been in use for some years, exclusive MC lanes are provided together with a setback storage space for left turning motorcyclists at a signalized intersection who are required to do a two-stage turn for safety reason. For an average traffic density of 2,000 CPU or more, Taiwanese traffic code suggests the setting up of exclusive MC lanes as follows: 1) for 1000 cars and 3300 Mcs, the configuration suggested is one car lane of width 3.5m and one MC lane of 2.0m 2) for 1800 cars and 660 Mcs, two car lanes should be put up and the MC rides non-exclusively on the kerbside strip; and 3) for 200 cars and 6000 Mcs, it is one car lane of width 3.5m and two exclusive MC lanes [16]. The above examples attest to the fact that standards governing MC riding and MC lanes differ from one country to the next. Nevertheless, some overseas practices can be emulated for the condition in Thailand; for example the state of Queensland's speed limit for lane filtering MCs which is set at 30km/hr [17]. MC lanes have been adopted in a number of Thai provincial cities including Phuket, Samut Prakan, Nakhon Pathom, Tak and Lampang. Design of these facilities has been "incomplete" due to its lack of exclusivity; for example, at an intersection or U-turn opening, the MC making a turn has to share lane with the car traffic. Only a small number of the urban roads have been designed with a MC lane, but it is often used as a car-parking lane. Notwithstanding such shortcomings, the MC lane still holds potential for further development, ideally as an integral part of road infrastructure to enable a better level of the safety for riders, a goal worth every dollar of investment. [18].

For this study, a number of local-area traffic modeling applications were assessed for their suitability, such as VISSIM, NETSIM, PARAMICS, AIMSUN, and CORSIM. Out of these, the VISSIM program was selected due to its ability to simulate the MC rider's behavior and MC traffic manipulation in much the same way as those for other types of road vehicles. With VISSIM, it is possible to specify the lateral clearance between two vehicles; or the position of a vehicle on a lane, i.e. left, right or middle. A vehicle can be made to overtake a slower machine in front and on the same lane. And while vehicles are waiting at a signalized intersection, the MCs may be simulated to weave in-between the lines of cars to fill gaps at the front of the traffic stream, thereby shortening the waiting lines [19]

The modeling program VISSIM 5.4 was chosen for this study primarily for its ability to simulate MC traffic to match our specified MC lane widths and configurations; and for its comprehensive range of other useful functions.

3. Methodology and Approach

The purpose of this study is to assess the range of MC lane widths and lane configurations using the approach described below:

3.1. Lane Configurations

Two lane types were investigated, namely the Shared Lane (SL), which allows other types of vehicles to share the MC lane; and Exclusive Lane (EL), which limits the lane use to only MCs. The parameters for model input were based on the followings: data compiled from the authors' previous studies of road accidents in Thailand between the years 2012 and 2014 [20]; and volumes of total traffic and volumes of MC traffic; traversing velocities at 85th percentile of MC speeds derived from actual surveys on urban and rural roads in the provinces of Songkhla and Narathiwat.

3.2. Lane Width Determination

The optimum lane width is determined from traffic simulation using VISSIM 5.4 with lane configuration and width data input, plus analysis of the modeling results in terms of relationships between MC volume, lane width and level of service (LOS). The input parameters for rider behavior were based on the values suggested by the program's user manual and field observations. MC dimensions were chosen at 1.8 to 2.0m in length and 0.8m in width which are considered appropriate to the traffic features of the test site.

3.3. Pilot Tests

Tests were conducted on a stretch of urban road in Narathiwat. MC lanes of varying widths were installed at the test site and the speeds of vehicles traversing the site were measured for each lane width. The relationship between lane width and the resulting traffic speeds was thus obtained. Using the conclusions of the study by Finch DJ, et al [10], a relationship can then be determined that links the drop in vehicle speed with the lane width and the resulting reduction in accidents by vehicle type.

4. Results and Discussion

4.1. Key data and Proposed Criteria for the Motorcycle Lane

From field data and the outcome of the authors' investigation, the key data and criteria for establishing the MC lane are described below:

- *Number of fatal and serious injuries – all vehicle types:* According to the accident statistics compiled by the authors, the rate of fatalities and serious injuries (or death-injury rate) involving all vehicle types on national highways during 2012–2014 was 24 cases per 100 km per year. Based on the cited figures, suitable parameters for death-injury rates may be derived for determining the optimum MC lane width. These are: 3 cases/10 km/year, for rural roads; and 6 cases/10 km/year for urban roads.
- *Volume capacity ratio (V/C):* For the pilot tests, a V/C ratio above 0.6 (0.61 to 0.70) was employed. This is equivalent to a B level of service (or LOS-B) which represents a traffic stream of moderate density where motorists experience some loss in vehicle maneuverability. The MC lane was configured as a Shared Lane. For the other configuration, i.e. the Exclusive Lane, a V/C ratio over 0.7, or LOS-C was used. At this level of service, motorists experience some tension in vehicular control as well as less opportunities for lane changing in mid-stream.
- *Number of MC accidents:* Data from the authors' study of MC accidents between the years 2012 and 2014 indicated an MC accident rate of 6 MC/100 km/year. For the purpose of the pilot tests, an MC accident rate of 1 MC/10km/year was adopted for tests on rural roads; and 4MC/10km/year, for tests on urban roads.
- *Motorcycle Volumes:* Analysis of the simulation results from VISSIM 5.4 indicated that on urban roads where the MC density is less than 600/hr/lane, it is feasible to install an MC shared lane having a LOS grading D. For MC densities higher than 600/hr/lane, an Exclusive Lane is preferable. A parallel situation is applicable to rural roads: Shared Lane for an MC density of less than 500/hr/lane; and Exclusive Lane for any density higher than that. An LOS grading of B with a minimum lane width of 2.0m should be used on rural roads.
- *Motorcycle Speed at 85th percentile:* Speed surveys conducted on the MC population on urban roads in Songkhla and Narathiwat provinces indicated an average MC speed of 32 to 35 km/hr, and the corresponding 85th percentile speed of 40–50 km/hr. And on rural roads in Songkhla the 85th

percentile MC speed was found to range from 40 to 80 km/hr. From the surveyed figures, the suitable 85th percentile values were derived thus: for urban roads, 45 km/hr and for rural roads, 60 km/hr.

Findings of the study are prescribed as the key data and criteria for establishing a motorcycle lane, as shown in Table 1. At any rate, the case for an MC lane needs not be fully covered by all of the criteria therein; an appraiser needs only to consider some of the relevant parameters that match the physical requirement of a location, or known characteristics that comply with the stated criteria.

Table 1. Key data and proposed criteria for establishing the motorcycle lane.

Description	Shared Lane		Exclusive Lane	
	Built up area	Non-built up area	Built up area	Non-built up area
Number of fatalities and serious injuries	Less than 6 cases/10 km/yr	Less than 3 cases/10 km/yr	More than 6 cases/10 km/yr	More than 3 cases/10 km/yr
V/C ratio	More than 0.6, or LOS B	More than 0.6, or LOS B	More than 0.7, or LOS C	More than 0.7, or LOS C
Number of MC accidents	Less than 4Crashes/10 km/yr	Less than 1Crash/10 km/yr	More than 4Crashes/10 km/yr	More than 1Crashes/10 km/yr
MC volume	Less than 600 MC/hr	Less than 500 MC/hr	More than 600 MC/hr	More than 500 MC/hr
MC 85 th percentile speed	Less than 45 km/hr	Less than 60 km/hr	More than 45 km/hr	More than 60 km/hr

4.2. MC Level of Service for Shared Lane

For the situation of a Shared Lane, a range of lane widths was inputted for simulation by VISSIM 5.4. Starting from 1.0m, the width was widened in step increments of 0.25m up to the width of 3.5m. as shown in the graph below. The outcome of the simulation enabled the analysis of the relationship between Lane Width, MC volume and LOS as shown in Fig. 1 below. The graph in Fig. 1 shows that lane widths ranging from 2.0m to 3.0m were able to accommodate MC volumes up to a maximum of 600 MC/hr at the maximum LOS at D level (LOS-D). And at LOS-D, the width of 2.0m was able to carry an MC volume of 180 MC/hr. Similarly, the 2.5m width could take up 320 MC/hr. (See graph below).

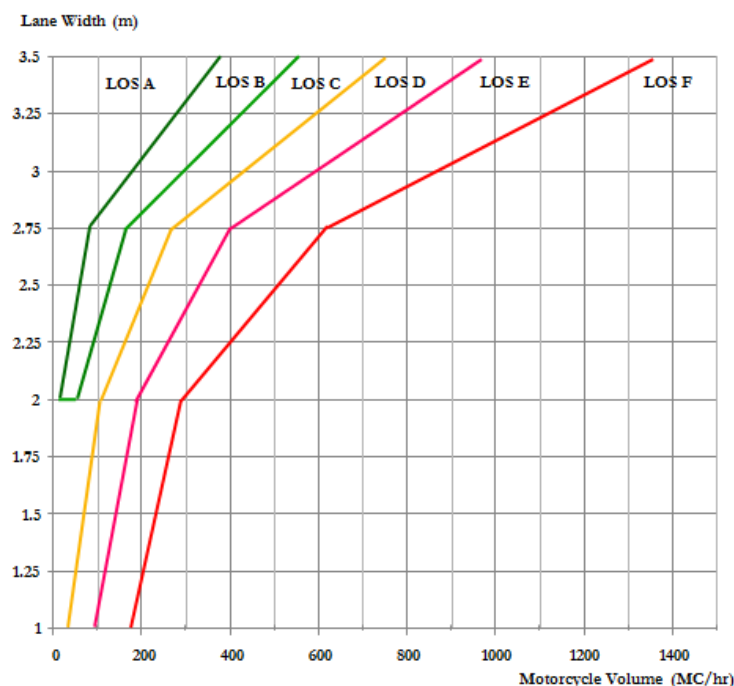


Fig. 1. Relationship between MC volumes, lane width and LOS, on shared MC lane.

4.3. MC Level of Service for Exclusive Lane

For an Exclusive Lane, the lane width parameters employed for simulation by VISSIM 5.4 was widened in step increments of 0.25m, starting from 2.0m up to 4.0m as shown in Fig. 2 below. The outcome of the simulation enabled the analysis of the relationship between Lane Width, MC volume and LOS as shown in Fig. 2. The graph in Fig. 2 shows that, at LOS-D, a 2.0m lane width was able to accommodate 1,000 MC/hr; a 2.5m width, 1,060 MC/hr; a 3.0m width, 1,120 MC/hr; a 3.5m width, 1,335 MC/hr. And the maximum width of 4.0m could take up 1550 MC/hr.

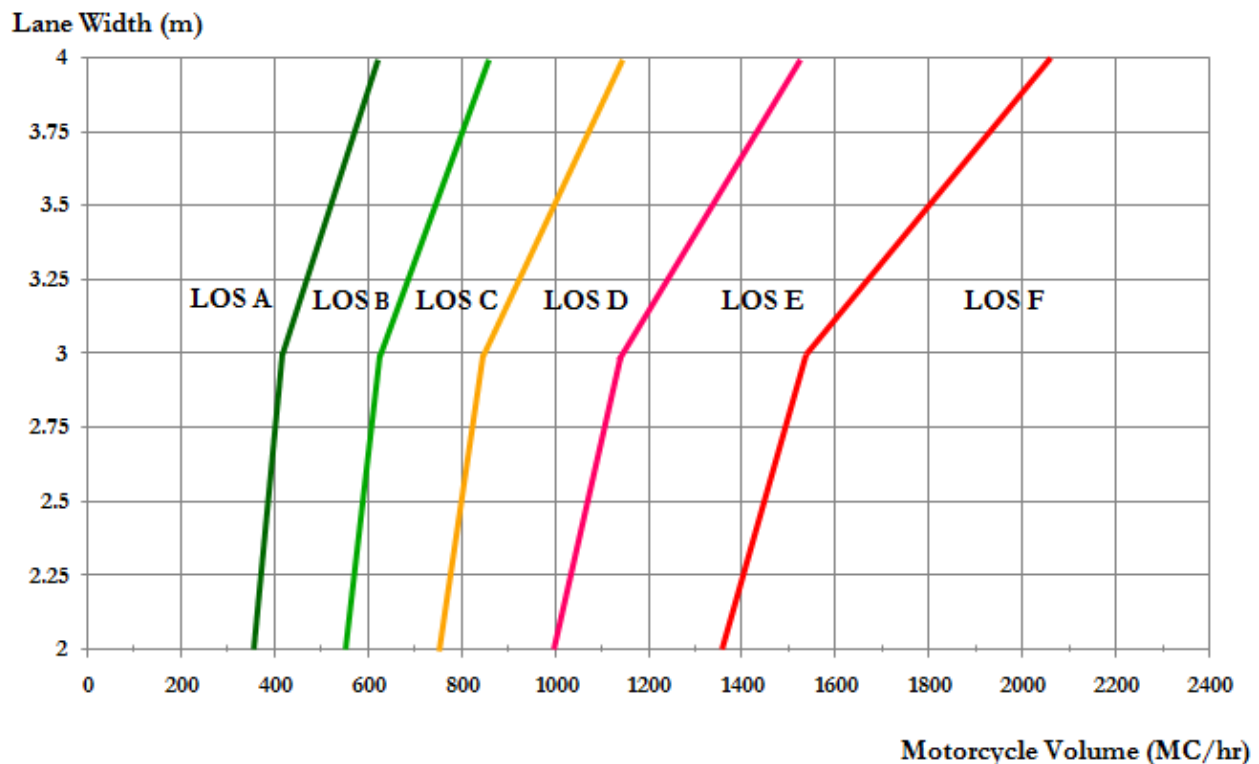


Fig. 2. Relationship between MC volumes, lane width and LOS, on exclusive MC lane.

4.4. Field Tests of MC Lane Configurations

Field tests were carried out in Narathiw province on a 4-lane stretch of an urban road with 2 lanes of traffic per direction. The tests were performed using a range of parameters as follows: V/C ratio of 0.6; 580 MC/hr density; MC accident rate of 2 Crashes/5 km/year; and an 85th percentile MC speed of 49 km/hr. On comparing the cited parameters against the key data and criteria, it was found that the V/C ratio, MC volume and MC accident rate match our criteria for the Shared Lane configuration. However, the 85th percentile speed did not match the criteria; and the death-injury figure was not available in this case. Despite the absence of the latter two parameters, the first three were considered sufficient for field testing a Shared Lane configuration. The tests were performed using three lane widths — 2.5m, 3.0m and 3.5m — as shown in Fig. 3. From the measurements carried out, it was seen that the installation of an MC lane led to a distinct reduction in the speeds of vehicles traversing the test site, as shown in Figs. 4 and 5. An exception should be noted in the case of MC speeds which showed increases in line with the widening of the MC lane.



Fig. 3. Field test of MC lane configurations on an urban road in Narathiwat.

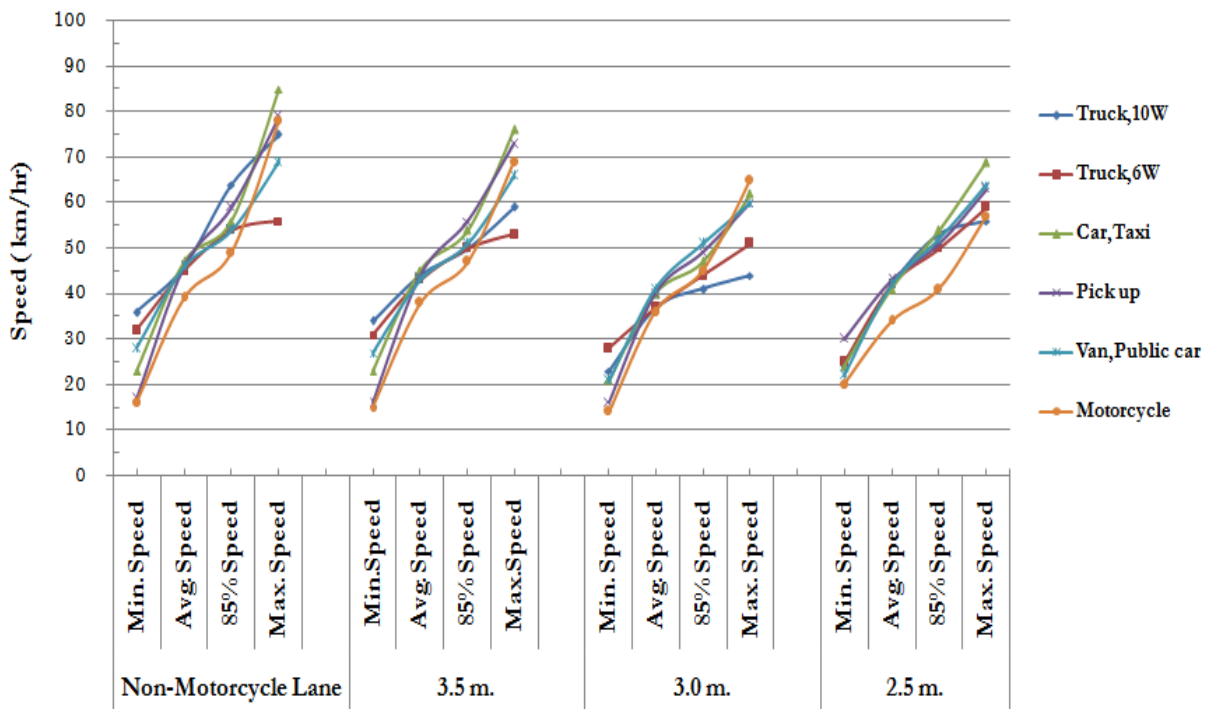


Fig. 4. Speeds of vehicle types in relation to varying MC lane widths.

From Figs. 4 and 5, it can be seen that the greatest reduction in vehicle speed occurs at the lane width of 3.0m. At this width, the speed of the 10-wheel trucks showed a maximum reduction of 36%, which corresponds to an accident reduction of 58.6%. This is trailed by the speed reductions of the 6-wheel trucks, the pick-ups, private cars, motorcycles, and vans and public cars. The reductions in speed as well as the corresponding drops in accidents are shown in Fig. 5, along with the average reduction in speed of 17% and its corresponding 25% drop in accident rate.

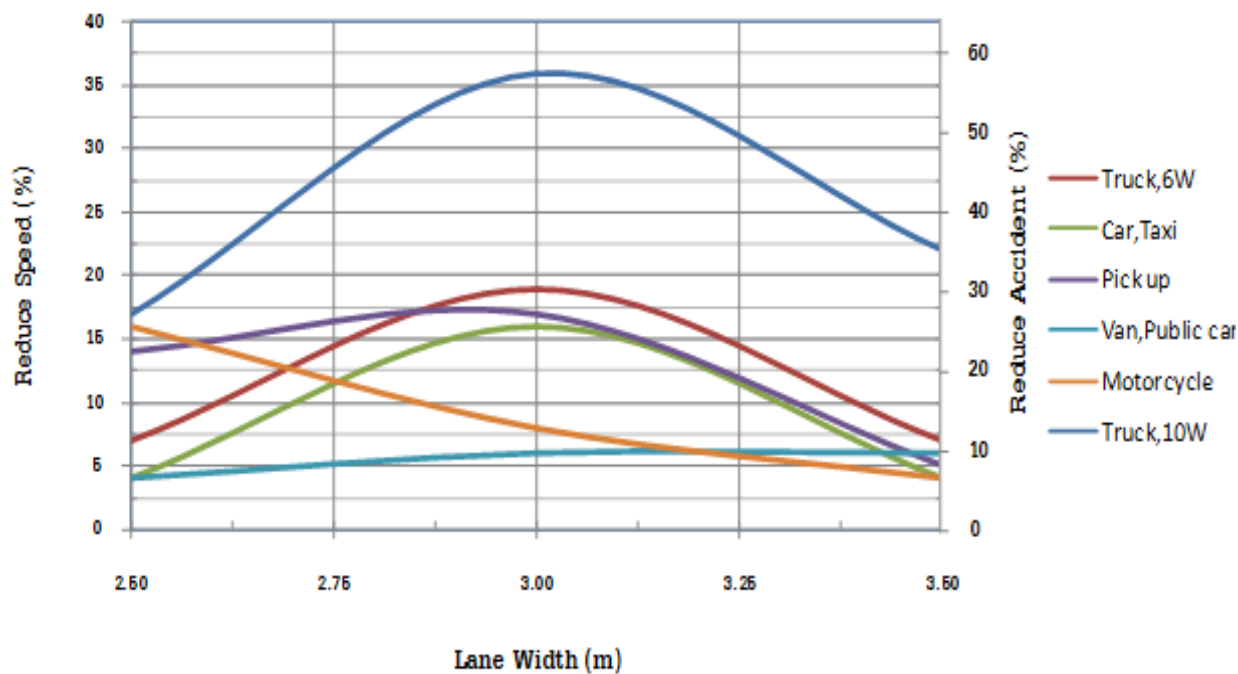


Fig. 5. Reductions in vehicle speed and accidents in relation to varying MC lane widths.

5. Conclusions

The Shared Lane and Exclusive Lane are the two configurations of MC lanes analysed in the study. The input parameters for simulation are as follows:

Parameter	MC Lane on a Rural Road	MC Lane on an Urban Road
Fatal/serious injuries	3 cases/10 km/year	6 cases/10 km/year
Number of MC accidents	1 Crash/10 km/year	4 Crashes/10 km/year
MC volume	500 MC/hr/lane	600 MC/hr/lane
MC 85 th percentile speed	60 km/hr	45 km/hr
	Shared Lane	Exclusive lane
V/C ratio	> 0.6 or LOS-B	> 0.7 or LOS C

Findings of the study indicated the optimum width of a Shared Lane lies in the range 2.0m to 3.0m. At these widths, the MC lane should be able to accommodate traffic from 180 to 300 MC/hr/lane. Widths greater than 3.0m will tempt the larger vehicles to stray into the lane, hence eroding its benefit for the MCs. On the other hand, a width less than 2.0m will most likely be too restrictive to provide any benefit (the typical body width of a motorcycle being 1.8m). The recommended width of 3.0m should provide an optimum benefit even when compared with 2.5m and 3.5m lanes. It has been tested and found to reduce the speeds of other traversing vehicles by 17% on average, which translates to an average reduction in accidents of 25%.

In the case of an Exclusive Lane, the recommended width is between 3.0m and 4.0m per direction depending on the volumes of traversing MCs. The Exclusive Lane may be divided into 2 sublanes, or 1.5m to 2.0m per sublane. In summary, the authors recommend configuring both the Shared and Exclusive

Lanes as 2-sublane per travelling direction, or 1.5m to 2.0m per sublane. Such a configuration should encourage the orderly riding of the MCs, and at the same time, provide ample room for coping with the future growth of the MC volumes.

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