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TITLE Preliminary analysis of exclusive motorcycle lanes along the federal highway F02, Shah Alam, Malaysia

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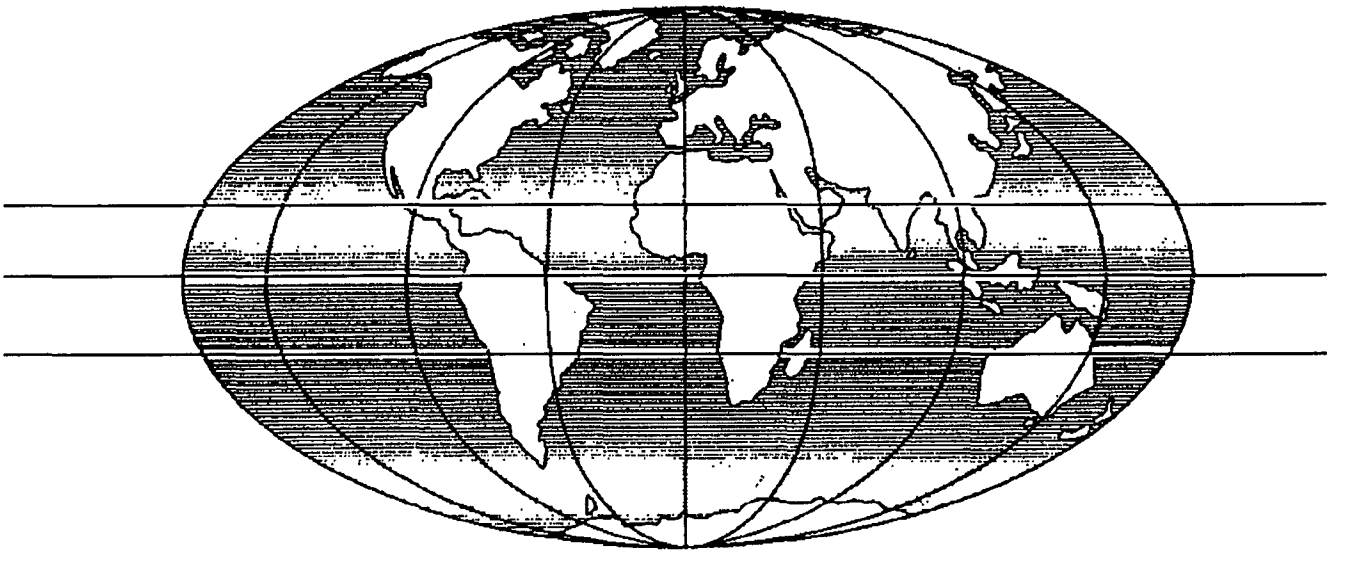

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PRELIMINARY ANALYSIS OF EXCLUSIVE MOTORCYCLE LANES ALONG THE FEDERAL HIGHWAY F02, SHAH ALAM, MALAYSIA

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One way to tackle the problem of motorcycle accidents between junctions (links) is to segregate motorcycles from other traffic using an exclusive motorcycle lane. This paper presents a preliminary analysis on the impact of the motorcycle lane in reducing link motorcycle accidents along Federal Highway F02, Malaysia. The study has shown that there has been a significant reduction ($p<0.05$) in motorcycle accidents following the introduction of the lane. The overall reduction of all motorcycle accidents along the 14 kilometre stretch is approximately 25%. When stratified motorcycle accidents are considered, the reduction of motorcycle accidents excluding the those that occurred on the main carriageway, is approximately 34%. Both reductions are highly significant at 5% ($p<0.05$) and 0.1% ($p<0.005$) for all motorcycle accidents and stratified motorcycle accidents respectively. These findings support the notion that segregating motorcycles from other traffic reduces the accident exposure and improves significantly the safety of motorcyclists.

Key words: Motorcycle accidents, Mixed flow, Traffic segregation, Motorcycle lanes

1. INTRODUCTION

On roads with high level of traffic, conflicts between vehicles may be created when heavy commercial vehicles and fast moving cars have to share the same roadway facility with the less protected and slower vehicles such as motorcycles, mopeds and bicycles. On these road sections, separation of motorcycle flows from other traffic will not only improve link accidents with motorcycle but can also improve the traffic flow especially when motorcycle traffic is heavy.

The concept of segregating vulnerable road users from other traffic is not new in the field of safety management. In many industrialised cities, traffic segregation, whereby pedestrians and bicyclists are segregated from motorised traffic[1,2,3,4], has long been recognised and forms part of the planning framework in the transport planning process. In developing countries, a number of studies[5,6] have also been carried out on the potential use of road marking installations for mixed flow conditions. Unfortunately, there has been little work and experiences so far on the use of exclusive tracks for motorcycles. Lack of commitment to plan safety strategies and financial constraints usually combine and result in shelving these measures. Perhaps, Malaysia might be the first country to implement this measure to promote safety for motorcyclists.

2. USE OF MOTORCYCLE LANES IN MALAYSIA

The notion of segregating motorcycles from other traffic by the use of a motorcycle lane is not new to Malaysia. In the early seventies, the first motorcycle lane was constructed along the Federal Highway Route 2, one of the busiest urban expressways in the country, under a World Bank project. The track consists of an exclusive 16 kilometer motorcycle track connecting the city of Kuala Lumpur and the Subang International Airport. For safety and accessibility of motorcyclists, grade-separated interchanges are used to connect the track with the main carriageway. Unfortunately, no study has so far been conducted to analyze the safety and economic benefit of the scheme.

In early 1992, an extension of the track was carried out. This extension was part of the improvement programme to the existing two-lane expressway connecting the Subang International Airport to the towns of Shah Alam and Klang. The project was constructed and managed by Projek Lebuhraya Utara Selatan (PLUS), under one of the government's privatisation schemes. In November 1993, major sections of the lane were completed ahead of schedule and it was opened for use by the public. This paper presents a preliminary analysis on the impact of the motorcycle lane on motorcycle accidents along Federal Route F02, within the city of Shah Alam, Malaysia.

3. METHODOLOGY

This study was based primarily on a specially created police accident form POL27(Pin 1/91) and the 24 hour police accident reports. The former was designed for easier completion and fully compatible with a customised version[7] of the TRL's Microcomputer Accident Analysis Package, MAAP[8] . Accident data were extracted from the four-year pilot project data[9,10] obtained in the districts of Seremban and Shah Alam since January 1991.

For each type of motorcycle accident, a detailed collision mechanism that lead to the accident was reclassified and recoded based on sketch diagrams and written police descriptions available on the last page of the police form. A total of 193 collision mechanisms divided into 37 colliding groups were identified[11] and summarised in Figure 1. The colliding group was classified according to the road geometry, vehicle manoeurvres and the right-of-way (ROW) with the notations S to represent all straight directions on ROW, T for turning on the ROW and X for crossing manoeuvres on losing ROW. Collision types were also identified by the impact directions with notations F, B and D for the front, rear and side collisions respectively. These recoded records were then manually updated into MAAP.

Analysis of the data was carried out using the cross-tabulation facilities available in MAAP, the time series cumulative plot[12] of monthly records and the traditional Chi-squared "before" and "after" analysis[13,14]. In this preliminary analysis, only the total motorcycle accidents were used. The detailed colliding mechanisms described in Figure 1, however, will be extensively used in the detailed and long-term analysis of the lane.

4. BASIC FEATURES OF THE MOTORCYCLE TRACK

Figure 2 shows a typical view of the extended track along the Federal Highway Route 2, Shah Alam. The extended track consists of a 14 kilometre exclusive track running alongside with the main three-lane urban expressway. The basic features of the motorcycle track are shown in Table 1.

Table 1 Basic features of motorcycle lane along Federal Highway Route 2

Motorcycle Lane Features	Design Parameter
Track length (Extension)	14 Kilometer
Track Width	2.5- 3.5 meter
Verge	1 - 2 meter
Distant from Main Carriageway	Varies with maximum 3 meter
Access Control	Full
Guardrail Type	Single face
Wearing Course Formulation	50mm Asphatic Concrete
Road Base Formulation	150mm Wet Mix Macadam
Sub-Base Formulation	250mm CBR>30%
Interchange	TypeGrade-Separated

(Courtesy from PLUS)

5. IMPACT OF MOTORCYCLE LANES ON ACCIDENTS

5.1 Time series plot of motorcycle accidents

The pattern of motorcycle accidents along the Federal Highway Route F02, 6 months following the introduction of the motorcycle lane is shown in Table 2. The cumulative plot of motorcycle accidents along the route and all accidents in Shah Alam is shown in Figure 3. In this analysis, all accidents in the city of Shah Alam were used as the control data. The rationale of chosing this as the control instead of all accidents along the whole route are (a) the main carriageway was also upgraded from the two-lane to three-lane expressway (b) the number of accidents exceeds (about 18 times higher) the number of motorcycle accidents.

From the above illustrations, it can be seen that the number of motorcycle accidents dropped markedly immediately following the opening of the motorcycle lane.The overall drop of motorcyce accidents along the route was approximately 25%. This drop can also be seen graphically from the clear downward separation of cumulative number of motorcycle accidents with respect to the predicted cumulative mean of accidents.

In contrast to the reduction of motorcycle accidents, the number of all accidents in the control area remains steady at an average rate of 235 accidents per month. The

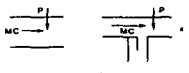
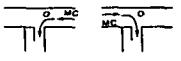
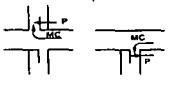
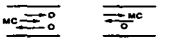
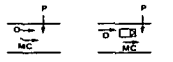
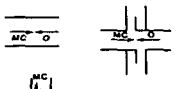
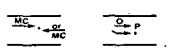
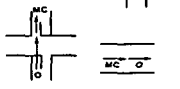
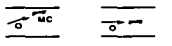
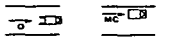
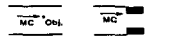
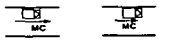
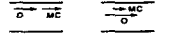
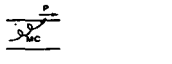
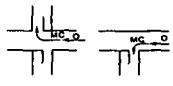
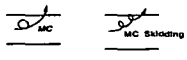
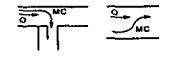
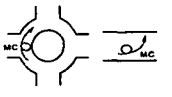
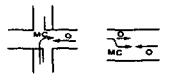
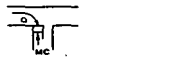
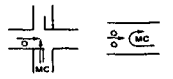
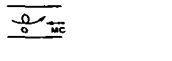
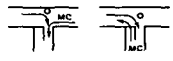
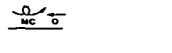
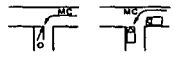
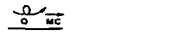
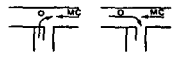
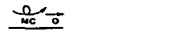
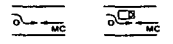
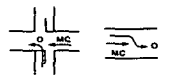
Notation	Colliding Machanism	Examples	Notation	Colliding Machanism	Examples
MCSPX	Motorcycle Straight Pedestrian Cross		MBOTB	Motorcycle Backing Other Turn Rear-End Collision	
MCTPX	Motorcycle Turn Pedestrian Cross		MSOSD	Motorcycle Straight Other Straight Side-Swipe Collision	
MSPOB	Motorcycle Straight Pedestrian Obscured		MSOSF	Motorcycle Straight Other Straight Head-On Cillision	
MSPMR	Motorcycle Straight Pedestrian Middle of Road		MBOSB	Motorcycle Backing Other Straight Rear-End Collision	
MSPWA	Motorcycle Straight Pedestrian Walk Along Road		MEOSB	Motorcycle Park/Stop Other Straight Rear-End Collision	
MSPWO	Motorcycle Straight Pedestrian Walk Opposite Direction		MSOEB	Motorcycle Straight Other Park/Stop Rear-End Collision	
MSHOJ	Motorcycle Straight and Hit Objects		MSOED	Motorcycle Straight Other Park Side Collision	
MCSHA	Motorcycle Straight and Hit Animals		MSORF	Motorcycle Straight Other Reverse Front Collision	
MCSHB	Motorcycle Straight and Hit From Back		MCYHP	Motorcycle Yaw/Fall and Hit Pedestrian	
MCTHB	Motorcycle Turn and Hit From Back		MYOFF	Motorcycle Yaw/Fall Off the Road	
MCXHB	Motorcycle Cross and Hit From Back		MYONR	Motorcycle Yaw/Fall On the Road	
MCXHF	Motorcycle Cross and Hit From Front		MQOTF	Motorcycle Queue at Stop Line Other Turn Hit From Front	
MCXHD	Motorcycle Cross and Hit From Side		MSOYF	Motorcycle Straight Other Yaw Head-On Collision	
MCTHD	Motorcycle Turn and Hit From Side		MYOSF	Motorcycle Yaw/Fall Other Straight Head-On collision	
MCTHF	Motorcycle Turn and Hit From Front		MSOYB	Motorcycle Straight Straight Other Yaw Rear-End Collision	
MSOXD	Motorcycle Straight Other Vehicles Cross Side Collision		MYOSB	Motorcycle Yaw/Fall Other Straight Rear-End Collision	
MSOXF	Motorcycle Straight Other Vehicles Cross Front Collision		MEOTB	Mototcycle Park Other Turn Rear-End Collision	
MSOXB	Motorcycle Straight Other Vehicle Cross Rear-End Collision				

Fig. 1 Detailed colliding mechanisms involving motorcycles in Malaysia

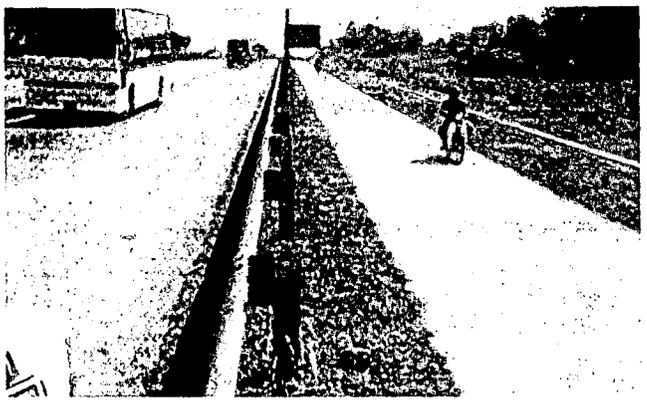


Fig.2 Typical view of motorcycle track along Federal Highway Route 2, Malaysia

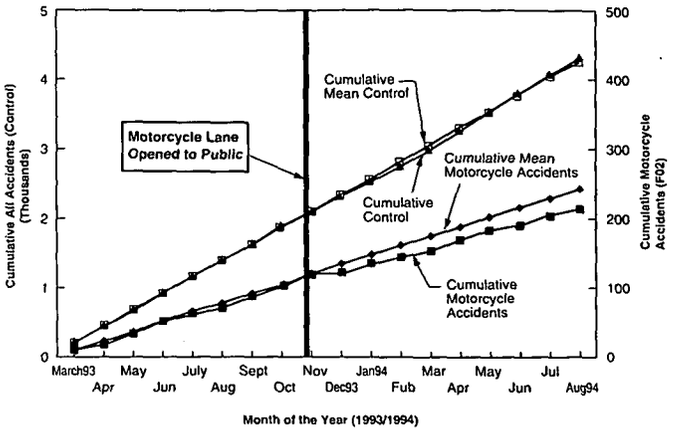


Fig. 3 Cumulative plot of motorcycle accidents along F02 and all accidents in Shah Alam

Table 2 Motorcycle accidents along Federal Route F02 Shah Alam

Before Period (March 1993- November 1993)									
Accident Type	**Mar93**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**
Motorcycle Accidents along F02	12	7	16	18	9	11	16	16	17
Cumulative M/C Accidents F02	12	19	35	53	62	73	89	105	122
Cumulative Mean M/C Accidents	12	26	39	53	66	80	93	107	120
All Accidents (Control)	236	256	237	230	230	225	232	267	205
Cumulative Control	236	492	729	959	1189	1414	1646	1913	2118
Cumulative Mean Control	236	471	707	942	1177	1413	1648	1883	2119
After Period (December 1993 - August 1994)									
Accident Type	**Dec93**	**Jan94**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug94**
Motorcycle Accidents along F02	2	13	8	10	16	12	9	13	10
Cumulative M/C Accidents F02	124	137	145	155	171	183	191	204	214
Cumulative Mean M/C Accidents	134	148	161	174	188	202	215	229	242
All Accidents (Control)	200	237	204	231	266	265	252	264	283
Cumulative Control	2318	2555	2759	2990	3256	3521	3773	4037	4320
Cumulative Mean Control	2354	2589	2824	3060	3295	3530	3766	4001	4236

number of accidents in the control area in the before period was 2118 while the after period was 2202.

To ascertain that the reduction is statistically significant, a more detailed anaysis is required. This can be achieved using the standard Chi-squared before and after study.

5.2 The Chi-Squared (χ^2) "before" and "after" analysis

The figures in Table 3 show a cross tabulation of aggregated all motorcycle accidents along F02 "before" and "after" the opening of the motorcycle lane. In this analy-

Table 3 Short -term analysis on motorcycle accidents along Federal Highway Route F02

Accident Type	Before Period (March -Nov93)	After period (Dec93 - August94)	Reduction (%)	χ^2	Probability
All Motorcycle Accidents Along F02	122	92	25	5.19	$p<0.05$
Stratified Motorcycle Accidents (F02)	122	81	34	9.51	$p<0.001$
All Accidents in Shah Alam (Control)	2118	2201			

sis, the motorcycle accidents in the "after" period were further classified into two categories:

(i) all accidents along the route, and
(ii) all accidents along the lane.

The rationale for this stratification is to separate all motorcycle accidents along the main carriageway and the accidents along the cycle track. This will allow for a more comprehensive assessment of the:

(i) actual impact of the lane,
(ii) compliance of motorcyclists to use the cycle lane,
(iii) the possible effect of incomplete track due to site constraints at kilometer 18.

It is worth mentioning that a small section of the cycle lane at kilometre 18 was still under construction after the official opening of the lane. This apparent delay was not due to any management and construction problems by PLUS but rather due to the fact that the whole construction was well ahead of the original schedule. Since it was wasteful to leave the lane unused and to wait for the original schedule, the management had decided to open the lane to the public at the earliest opportunity. During this study period, motorcyclists however had to join the main expressway for a short distance before rejoining back to their cycle track.

Based on this "before" and "after" analysis, it can be stated that the introduction of a motorcycle lane has significantly reduced motorcycle accidents along the route. The computed χ^2 value for one degree of freedom is 5.19 and the reduction is significant at 95 percent confidence level ($p<0.05$). When stratified data is considered, the impact of the motorcycle lane in reducing motorcycle accidents is more distinctive with the χ^2 value of 9.51 ($p<0.005$).

6. DISCUSSION

The above study deals only with the short-term impact on the use of motorcycle lane along Federal Route 2, Shah Alam, Malaysia. This preliminary analysis has shown the introduction of the lane has significantly reduced motorcycle accidents along the route.

No direct comparison can be made on the benefits of the motorcycle lanes, since no other research has been carried out or reported before. However, the success of this traffic segregation scheme is in line with the concept of segregating bicycles from other traffic in many developed countries. In Japan[4], it was reported that vehicle to bicycle accidents decreased by 15.4% following the introduction of bicycle-pedestrian path. This study was based on a before and after comparison of 96 locations in Japan where the path had been installed between January 1986 and June 1987. In another study on the effect of the Western approach cycle route in Southampton[3], it was reported that although there was no change in the total number of about 12 bicycle accidents per year on the route, cycle flow increased by 28% when flows declined 14% elsewhere in the city. Thus, it was interpreted that the initiative reduced the cycle accident rate along the route.

Although the exact explanation of the reduction of motorcycle accidents following the lane construction is yet to be examined, a number of factors can be put forward to the success of the scheme. Segregating slow moving motorcycles from fast moving traffic, particularly the low cc motorcycles, would eliminate traffic conflicts and speed differentials between motorcycles and faster vehicles. This idea is in agreement with the fact that approximately 99% of the rear-end accidents with motorcycles between 1991 and 1993 in this pilot areas involved lower cc, slow motorcycles. This concept is also in agreement with Munden[15] who established the U- shaped variation of accident rate

and relative speed; the fastest and slowest drivers have higher accident rates than the average speed drivers. Thus segregating motorcycles from other traffic will eliminate these speed differentials, provided that they stay away from the main carriageway.

In this research, it has also been shown that when data are stratified according to the exact location of the accidents, whether on the track or on the main carriageway, the reduction in motorcycle accidents is more significant in the case of stratified data. This implies that there is still a sizeable number of motorcyclists who stayed on the main carriageway instead of riding on the cycle lane. This might be the result of (i) the higher cc large bikes which were given the option to use either route of the expressway and (ii) the enforced joining of the main traffic at kilometre 18 of the carriageway. However, no research has been carried out to substantiate this hypothesis.

The change in riding environment is one of the important factors in influencing the safety of motorcycles. This is because, riding a motorcycle differs fundamentally from driving a car in terms of its stability. Adverse weather conditions, poor road surfaces such as pot holes, oily and sandy roads[16] and aerodynamic disturbances from larger vehicles[17] can easily cause a motorcycle to become unstable. Thus creating a safer riding environment by means of exclusive lanes would contribute to the lower number of these types of motorcycle accidents.

7. CONCLUSIONS

This preliminary analysis suggests that traffic segregation by means of exclusive motorcycle lanes may prove to be one of the best ways to achieve the desired safety objective particularly along routes with a high population of motorcycles. This is because it reduces the number of motorcycle accidents dramatically following the intervention. The overall short-term reduction was found to be 25% and significant at the 5% ($p<0.05$) level. If accidents along the main carriageway are excluded, the reduction was 34% and significant at the 0.5% ($p<0.005$) level. Besides solving the problems of speed differentials and mixed flow problems of the incompatible traffic, this measure also creates better driving environments for both motorcyclists and other road users.

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