A comparison study on motorcycle traffic development in some Asian countries – case of Taiwan, Malaysia and Vietnam

Final Report

Principal Researcher:
Dr. Ing. Hsu, Tien-Pen
Institute of Civil Engineering
National Taiwan University, Taiwan

Co-Researcher:
Dr.-Eng. Ahmad Farhan Mohd Sadullah
Department of Civil Engineering
University of Science Malaysia, Malaysia

Dr.-Ing. Nguyen Xuan Dao
Research Institute for Transportation science & technology,
Ministry of Transportation, Vietnam.

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CHAPTER 1. INTRODUCTION

1.1 Background

Mixed traffic with motorcycle is a major traffic type in some Asian countries, for example, in Taiwan, Malaysia and Vietnam. Traffic mixed with motorcycle will become more hazardous under interruption caused by motorcycle. Understanding motorcycle traffic development situation will help policy makers find the most appropriate policies to enhance the traffic performance on the roads. It may also help the industry to supply motorcycles with the right marketing strategy. Taiwan, Malaysia and Vietnam are three countries, which are the subject of this study. These three countries face their own situation with respect to the high motorcycle traffic volume, but each country has different economic development level. Taiwan is a high-income country, while Malaysia belongs to the middle-income level or so called newly industrialized country, and Vietnam is a typical country with low income but with high potential and high mobility to pursue future economic growth.

In these countries, the street system was designed and constructed with respect to car traffic and was much influenced by technology and construction techniques originating from western countries. The design concept of streets in Taiwan was mainly from America; the design concept in Malaysia was mainly from England; and the design concept in Vietnam was mainly French. Traffic in Taiwan and Vietnam drive on the right side, while traffic in Malaysia is on the left side. However, the difference in the side of driving does not influence motorcycle traffic characteristics, because the handling of motorcycle is not distinguished by whether it is on the right side or the left. However, motorcycles are still in the same road space as cars. The mixed traffic causes conflict among vehicles driving on links and when at intersections. The conflict between motorcycles and other vehicles will become more serious near a bus stop or when a curb-parking vehicle interrupts flow. It is therefore imperative that discussion on the traffic situation in these three countries is made to help understand the traffic problem and the possible problems caused by motorcycles.

1.2 Scope of work

This study is a collaborative research involving researchers from Taiwan, Malaysia and Vietnam. The following activities were conducted and may be treated as the work scope of this study:

a) To carry out a survey of motorcycle traffic volume in a mixed traffic

situation, involving three selected sites in a typical metropolitan area. In addition, the existing secondary data from survey conducted in the respective countries will be collected and analyzed for better understanding and comparison of the traffic volume situation between the three countries.

b) To collect the official statistical data of motorcycle ownership and usage in the past, and to analyze the reason behind the high motorcycle demand.
c) To collect the existing related studies within the country, if it exists, for understanding the attributes of motorcycle ownership and usage and the forecasting perspective.
d) To collect and summarize the existing countermeasures of enhancement of motorcycle traffic performance
e) To analyze the existing motorcycle-related traffic problem, including traffic efficiency, parking issues, and traffic safety issues.

Besides discussing and exchanging experience between the professionals of each participating country, during the study, two symposiums were organized. One was held in Taiwan in November 2002, and the other in Malaysia in August 2003. Motorcycle traffic situation in Vietnam has been experienced during the 4th EASTS conference held in Hanoi in the year 2001. At the symposium, the researchers presented the prevailing motorcycle traffic development to provide the background for opinion and experience exchange.

From the research, it was apparent that Taiwan has developed many traffic management measures to response to the high motorcycle demand in the highly mixed traffic road thoroughfares. Management schemes such as the guideline for motorcycle exclusive lane, setback-waiting space for motorcycle at signalized intersection, the two-stage left-turn traffic control countermeasure for left-turn motorcycle and others are summarized in this report. These measures seem to be a logical basis in creating a countermeasure handbook for motorcycle traffic for the region in the future. A concept for possible deployment of intelligent transportation system (ITS) for motorcycles will also be discussed.

CHAPTER 2. Demography and Traffic Situation in Asian Countries

2.1 Socio-economic situation of Asian countries

Most Asian countries are now undergoing rapid economic development. At present, only Japan and Singapore may be considered as developed high-income countries. Other countries belong to the middle and low-income country categories. In these countries, motorcycle is the main individual vehicle choice for mobility. The labor force by sector may also influence the ownership and usage of motorcycle. In low-income countries, majority workers of the industry sector use motorcycles. Table 1 shows the Gross Domestic Product (GDP) per capita and the labor structure by sector with the registered number of motorcycles.

Table 1. Economic and motorcycle ownership (2001)

Country	GDP per Capita (US$)	Labor force by occupation (%)			Number of Motorcycles	Number of Cars
		Agricul-ture	Industry	Service		
Japan	28,000	5	25	70	14,536,512[a]	48,684,206[a]
Taiwan	17,200	8	36	56	11,733,202	4,825,581
Malaysia	9,000	16	27	57	5,609,351	4,557,992
Vietnam	2,100	67	15	18	8,395,835	532,681
China	4,600	50	23	27	31,619,000[b]	7,402,300[b]
India	2,540	60	17	23	25,915,000[c]	4,682,000[c]
Indonesia	3,000	45	16	39	13,563,017[d]	3,038,913[d]
Thailand	6,600	54	15	31	13,244,961[e]	2,123,590[e]

(Note: The economic data resources are combined from various statistics website.

a: data of 1997; b: data of 1999; c: data of 1997; d: data of 2000; e: data of 1999)

The high motorcycle volume is a unique traffic situation of the Asian Countries. Motorcycle ownership and usage in Asia may be influenced by factors different from those for the western countries. Factors may include the weather, the economy, the population density and the cultural background. As motorcycles-related problems are on the rise in Asian countries, and as they are a unique problem of the region, the solution champion has to be the professional experts from Asia.

2.2 Traffic situation and motorcycle issues

Resulting from the field observation made on the existing mixed-traffic situation in these three countries, the common characteristics of motorcycle traffic can be identified and are described as follows:

- Motorcycles area relatively small in size, giving maneuvering flexibility and the freedom to park practically anywhere.
- Motorcycles have the agility and the capability to weave through queues in congested areas.
- The weight of a motorcycle is relatively light and able to be moved by driver.
- The price of motorcycle is low and affordable by many people in developing or in the low-income economies.
- The safety concern is one of the main reasons against the development of motorcycles. The motorcycle is seen as one of the more hazardous mode of travel.

Despite many similarities, several differences were identified between the situations in Taiwan, Malaysia and Vietnam, and they are as follows:

- The traffic volume in each country has different composition of motorcycles for different road types and hierarchy. The dominance of motorcycles in the traffic flow may show the dependency of the people of the country on motorcycles. From this study, the level of dependency on motorcycles in these three countries varies, with Vietnam being most dependent and Malaysia with the least dependency on motorcycles. However, in general, major corridors for commuting traffic in these three countries all have very high motorcycle traffic volume.
- Motorcycle will not follow the “First In First Out” rule at intersections with queues. Due to its high maneuverability, motorcycles will almost always attempt get in between queuing vehicles to get to the front of the queue. The situation in Vietnam is the most serious compared to Malaysian and Taiwan due its extremely high traffic composition of motorcycle.
- Attempts to segregate motorcycles from the main traffic have been made in Taiwan, and will lesser degree in Malaysia, but not in Vietnam. In Taiwan, segregation is deployed in urban areas, where specific motorcycle lanes are built to segregate motorcycles from other traffic. In Malaysia, segregation only happens at some freeways, and physical segregation with raise curb is needed to give exclusivity and to avoid infringement from other traffic.
- There are different traffic regulation rules concerning motorcycles on freeways.

In Taiwan, motorcycles are prohibited from driving on freeways and expressways, while they are allowed in Malaysia and Vietnam.

- The traffic regulation and management in Malaysia and Vietnam do not make any distinction between motorcycles and other traffic at intersections. However, in Taiwan, the motorcycle is seen as a different mode and has its own regulation. For example, at any big intersection, motorcycles are prohibited to make a left-turn directly; even at intersections with protected left-turn phase for car traffic, the motorcycle has to left-turn with two stages.
- Motorcycles usually park on the pedestrian sidewalk in Taiwan and Vietnam. In Malaysia, motorcycles usually park on the pavement of the street, and most often will have designated parking bays. However, in the past two years, Taiwan has begun to change the situation to redesign the sidewalk with parking bays for motorcycle by leaving the sidewalk free from parked motorcycles. This has made walkways friendlier for pedestrians. The off-street parking of motorcycle is not popular in Taiwan. In all three countries, motorcycle parking is free, while car parking is normally with some nominal fee.
- Motorcyclists must wear safety helmet in Malaysia and Taiwan, but there is no such regulation in Vietnam. Only in Malaysia, motorcycles must drive with running headlight at anytime. In Taiwan, there is an experimental implementation of running headlight for motorcycles in mountainous area.
- The size of motorcycle engine in Vietnam and Malaysia is predominantly made up of those under 100 cc. In Taiwan, there are also many 100cc motorcycles but none exceeds 150cc as recently, motorcycles with more than 150cc is no longer allowed in Taiwan. The motorcycle type in Taiwan is mostly made up of the modern scooter type, while a mixed type may be found in Vietnam and Malaysia. The price of motorcycle in Taiwan is comparatively more expensive than those in Malaysia and in Vietnam.
- Enforcement is seen as a good measure to improve the traffic order and to enhance the traffic safety of motorcycles. However, enforcement is usually difficult to implement. In Taiwan, and Malaysia the enforcement against motorcycle is becoming more aggressive in recent years, while in Vietnam, there is virtually no enforcement.
- A national policy for motorcycle traffic is normally ignored in the past in these countries. There is still no motorcycle specific national policy announced in Malaysia and in Vietnam in the past. In Taiwan, the first national policy for motorcycles was made in 1997 (MOTC, Taiwan, 1997).

The following pictures illustrate the prevailing motorcycles traffic situation in these three countries:

Picture 1: Curbside motorcycle parking in Malaysia

Picture 2: Motorcycle driving within the platoon of cars without specified space in Malaysia

Picture 3: Motorcycle stopping over the stop line without specified waiting space in Malaysia

Picture 4: The street is full of motorcycle, congested motorcycle flow in Vietnam

Picture 5: Motorcycle priority lane in Tainan, Taiwan

Picture 6: Motorcycles at intersection during red light in Taipei, Taiwan

Picture 7: Congested mixed-traffic at an intersection in Taipei, Taiwan.

Picture 8: Motorcycle curbside parking bay next to sidewalk in Taipei, Taiwan

Motorcycle issue is a complex one, and has often been neglected in the past. Most researches made and policies issued in the past were with the viewpoint of automobile. And this is despite the fact that motorcycle rider being seen as the

vulnerable groups for a long time. The issues concerned may include the ownership and usage problem, the motorcycle contribution to the traffic flow and how they influence capacity and traffic performance. High in the agenda is also the motorcycle safety problem, and the motorcycle contribution to environmental pollution. Methods of enforcing on motorcycle traffic are also a difficult but important issue.

CHAPTER 3. Economic Growth and Motorcycle Ownership

3.1 Economic growth and motorcycle ownership

Taiwan has seen very rapid economic growth recently. An analysis on the growth of motorcycles has shown its strong correlation with the GDP growth, as illustrated in Figure 1. The number of motorcycle still experience high growth rate even when the economic level of Taiwan is closing to achieving the high-income economy status.

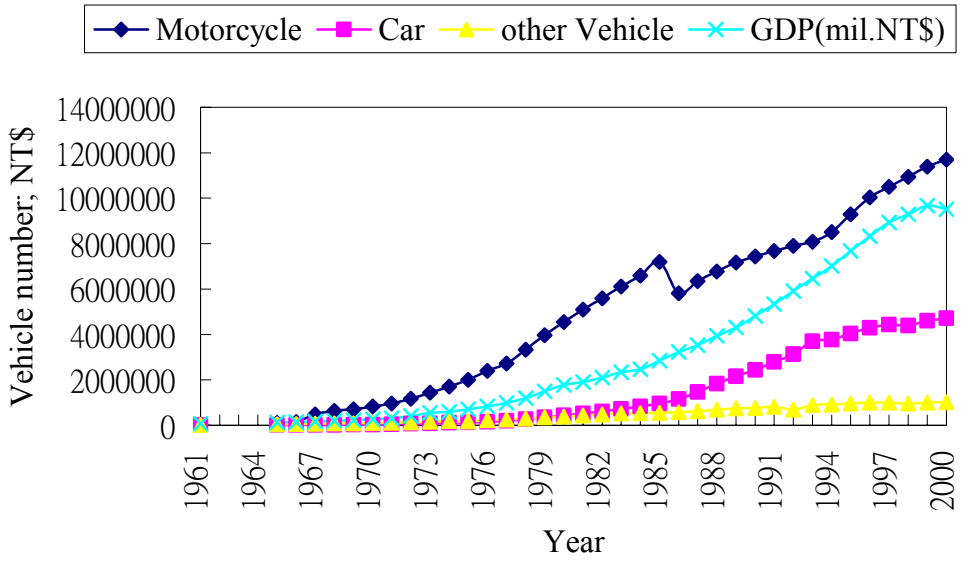

Figure 1: GDP and registered motorcycle and car number of Taiwan

Vietnam has seen even a more drastic increase in number of motorcycles recently, as illustrated by Figure 2. In Vietnam, the booming motorcycle traffic may be a reflection of its changing living standard. Many Vietnamese nowadays consider motorcycle as the most suitable vehicle for their private transport. The tropical climate in Vietnam is also a good reason for people to use motorcycle. The poor urban public transport system in Vietnam's two biggest cities Hanoi and Ho Chi Minh City (HCMC) may be the main reason why people prefer motorcycles, and have subsequently resulted in the traffic chaos often experienced in these two cities. Newly set-up bus-lines in Hanoi and HCMC can attract only 5% of travel demand. Statistics show that almost 90% of travelers use private forms of transport.

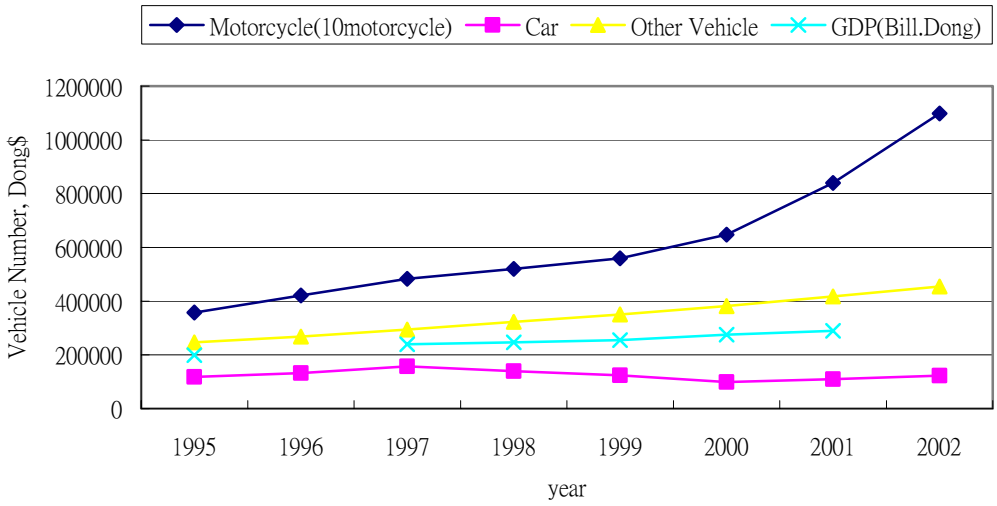

Figure 2: GDP and registered vehicle of Vietnam

In Malaysia, the traffic system is more car-oriented. However, motorcycle also dominates the road space. Motorcycles and cars have the similar growth trend, as may be seen in Figure 3. In Malaysia, a motorcycle is often the first choice of private transport for a new worker. However, once one progresses in his career, he or she would often save to buy a car. Especially, when this is coincided with the time they enter marriage life. This situation is not similar with the situation in Taiwan, where people will have a motorcycle and a car at the same time. The reason may possibly be the fact that Taiwan has a higher population density than Malaysia.

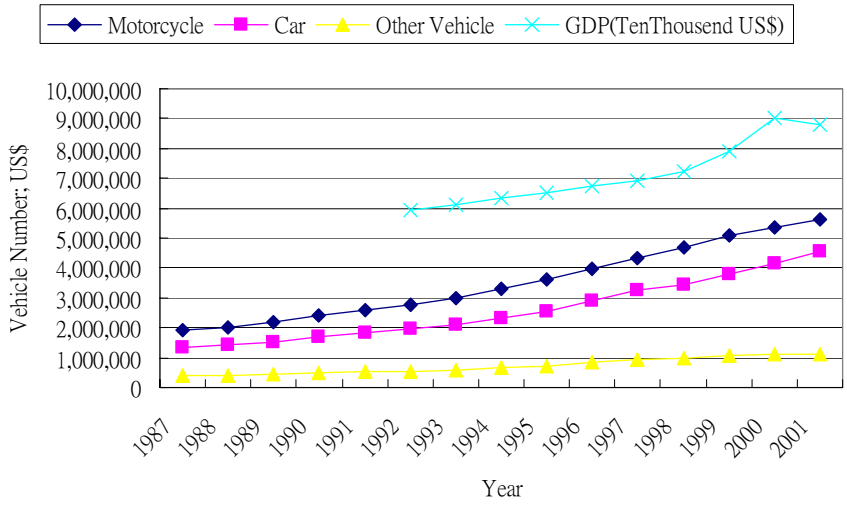

Figure 3: GDP and registered vehicle in Malaysia

3.2 Registration of motorized vehicles

In Taiwan, motorcycle registration has consistently dominated the vehicle registration in the past. However, car ownership has recently picked up, but is still low compared to motorcycles. Table 2 shows the record on vehicle registration in Taiwan.

Table 2: Registered vehicles and ownership of Taiwan

year	car	motorcycle	Other motorized vehicles	car/ 1000p.	Motorcycle /1000p.	Other vehicle /1000p.	All/1000 persons
1992	2,900,042	7,649,308	718,904	140	369	35	543
1993	3,238,754	7,867,396	750,374	155	376	36	566
1994	3,570,497	8,034,509	772,076	169	379	36	584
1995	3,874,203	8,517,024	810,244	181	399	38	618
1996	4,146,475	9,283,914	843,076	193	431	39	663
1997	4,411,911	10,051,613	882,219	203	462	41	706
1998	4,545,488	10,529,040	884,607	207	480	40	728
1999	4,509,430	10,958,469	849,869	204	496	38	739
2000	4,716,217	11,423,172	883,300	212	513	40	764
2001	4,825,581	11,733,202	906,254	215	523	40	779
2002	4,989,336	11,983,757	933,864	222	532	41	795

Figure 4 shows that the share of motorcycles compared to other registered vehicles have consistently been above 50% for Taiwan.

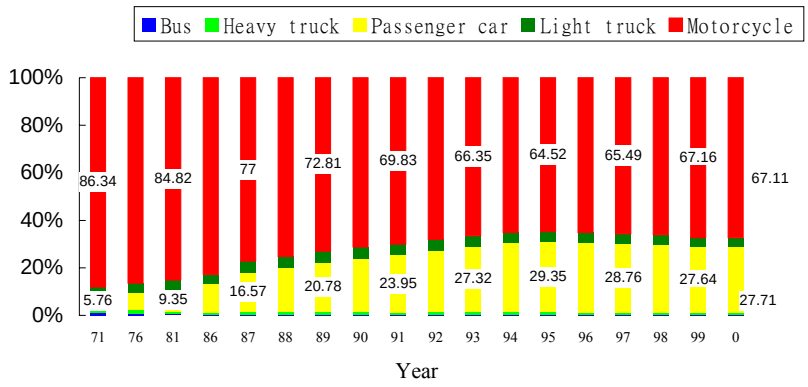

Figure 4: Proportion of the motorcycle and car ownership in Taiwan

In Malaysia, car registration makes up around 35% of the total registered vehicles, while motorcycles make up around 50%. The vehicle registration record for Malaysia is illustrated in Table 3 and Figure 5.

Table 3: Vehicle registration in Malaysia

YEAR	Motorcycle	Car	Bus	Taxi/Hire Car	Goods Veh	Others	Total
1990	2,388,477	1,678,980	24,057	35,405	288,479	132,016	4,547,414
1991	2,595,749	1,824,679	26,147	38,477	313,514	143,472	4,942,038
1992	2,762,666	1,942,016	27,827	30,953	333,674	152,698	5,249,834
1993	2,970,769	2,088,300	29,924	44,040	358,808	164,199	5,656,040
1994	3,297,474	2,302,547	33,529	47,512	393,833	178,439	6,253,334
1995	3,608,475	2,553,574	36,000	55,002	440,723	203,660	6,897,434
1996	3,951,931	2,886,536	38,965	59,456	512,165	237,631	7,686,684
1997	4,328,997	3,271,304	43,444	62,119	574,622	269,983	8,550,469
1998	4,692,183	3,452,852	45,643	64,632	599,149	286,898	9,141,357
1999	5,082,473	3,787,047	47,674	65,646	642,976	304,135	9,929,951
2000	5,356,604	4,145,982	48,662	66,585	665,284	315,687	10,598,804
2001	5,609,351	4,557,992	49,771	66,565	689,668	329,198	11,302,545

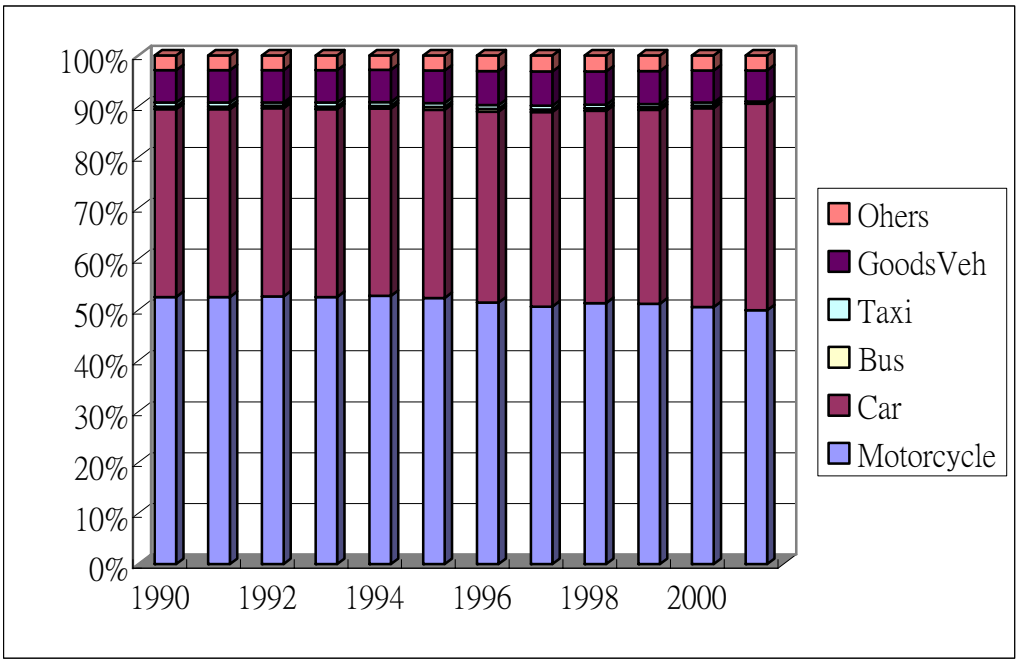

Figure 5: The proportion of the registered vehicle and motorcycle in Malaysia

In Vietnam, motorcycles dominate and make up more than 90% of the registered motorized traffic. Table 4 shows the detail of the registration record.

Table 4: Vehicle registrations in Vietnam

		Motorcycle				
Vietnam car		Number	% of all	Bus	Truck	all
1990	246194	1209463	85.1	32318	163284	1651259
1991	256898	1522184	87.3	34305	201849	2015236
1992	270036	1704225	87.6	37911	161044	2173216
1993	292899	2427163	90.1	34305	201332	2955699
1994	307078	3052847	91.4	42566	174412	3576903
1995	340779	3578156	91.8	60356	186796	4166087
1996	386976	4208247	92.0	66453	201368	4863044
1997	417768	4827218	92.0	NA	NA	5244986
1998	443000	5200000	92.1	NA	NA	5643000
1999	456000	5600000	92.5	NA	NA	6056000
2000	486000	6478000	93.4	53122	328622	7345744
2001	532681	8395835	94.3	72845	344423	9345784

3.3 Motorcycle Ownership and Type of motorcycles

Motorcycle ownership is much influenced by the advantages they have, which include:

- Motorcycle is much cheaper than the car.
- Motorcycle needs less space for parking; it can be put anywhere in front of the house.
- Motorcycle usage is convenient and provides door-to-door access.
- Motorcycle may get through congested queue through its weaving maneuver, has a good acceleration rate and may cruise (especially in urban areas), as fast as a car.

Despite these advantages motorcycles have several disadvantages, which may influence its ownership, such as

- Not protected from weather,
- Does not provide protection to the driver
- Require balancing when operating and is inconvenient to carry high number of passengers as well as not suitable for bringing goods.
- Having a high degree of exposure which makes passengers more vulnerable during a collision.

However, despite these disadvantages, motorcycles are still very attractive to many people in developing countries, especially in the Asia region. The motorcycle ownership situations in these three countries are of special interest, because they have different economics development levels and have contributed differently to the development of motorcycle traffic.

It is often hypothesized that motorcycle ownership would decline as the country enjoy economic growth. However, in Taiwan, the motorcycle ownership has not declined despite its continued economic growth. This is illustrated in Table 5. This hypothesis was based on the experience in many developed countries. Based on this hypothesis, one day, due to the continuous decline, motorcycle will become the minority mode in the traffic stream. Based on this hypothesis, many professionals in Taiwan forecasted that number of motorcycles registered would be decreasing with time and will not become significant in the future. However, as shown by Table 5, this has not happened ant the opposite is the reality.

A closer scrutiny into the situation in Taiwan revealed that the situation is actually expected, despite Taiwan now having income more than US$ 15,000 in urban areas. The need for mobility remains very high, and added with the traffic congestion and parking difficulty for cars in the city area, many are finding motorcycles as the better alternative, even if they can afford a car. This is also despite the fact that driving a motorcycle is more hazardous. As a result, Taiwan now has the highest motorcycle ownership in the world with 523 motorcycles per thousand people, as shown in the Table 5. The exact reasons causing the high ownership of motorcycle in Taiwan are still not fully known. However, preliminary studies suggest that the many people in Taiwan use motorcycles for their daily travel mode because of their high mobility and versatility, cheap and convenient. For the year 2001 Taiwan has 1.726 motorcycles per household compared to 0.843 cars per household. Figures in Table 6 illustrate that on the average, a household in Taiwan has more than one motorcycle and about one car at the same time. This suggests that motorcycles are not replacing car ownership, but people in Taiwan are buying motorcycles to complement their car usage. This fact may have contributed to the present nature of vehicle ownership in Taiwan.

Table 5.Car and Motorcycle ownership in Taiwan, Malaysia and Vietnam

Country (Year)	Car (veh)	Motorcycle (veh)	Car Ownership (veh/1000p)	Motorcycle Ownership (veh/1000p)
Taiwan (2001)	4,710,675	11,704,003	205	523
Malaysia (2000)	4,145,982	5,356,604	178	230
Vietnam (2001)	532,681	8,395,835	7	107

Table 6: Motorcycle and car number of household of Taiwan

Year	Motorcycle per Household	Car per Household
1991	1.426	0.614
1992	1.438	0.677
1993	1.442	0.727
1994	1.434	0.771
1995	1.467	0.807
1996	1.545	0.831
1997	1.621	0.854
1998	1.654	0.853
1999	1.678	0.821
2000	1.710	0.839
2001	1.726	0.843

In Malaysia, the road system has always been developed based on the car orientation. Nevertheless, motorcycles still have the larger share of the vehicle registration as may be seen in Table 7. Unlike the situation in Taiwan, the high motorcycle ownership in Malaysia may be contributed to the purchasing capacity of its people. The car will be the first choice for many if they can afford one. Some distinct features of motorcycle ownership in Malaysia are as follows:

- Motorcycle often becomes the first private vehicle purchased by a new worker due to its limited purchasing capacity.
- Motorcycle is a popular choice of vehicles to low to middle income groups especially in urban cities.
- Motorcycle is also a popular choice of mode in rural areas, especially for short distance travel.

The motorcycle ownership per thousand people in Malaysia is almost the same with car ownership, as shown in Table 7. Despite having a steady increase in motorcycle registration, Malaysia has not experiences the drastic increase as seen previously in Taiwan and presently in Vietnam. A logical conclusion can be made that Malaysians will use motorcycle in the absence of or in the inability to own a car. Motorcycles in Malaysia are typically small in size (under 150 cc), however, lately bigger motorcycles are become more appealing to high income riders. They use bigger motorcycles for recreational purpose, but the impact of this new ownership behavior is yet to be traceable in the official vehicle registration statistics.

Table 7: Car and Motorcycle ownership per 1000 persons in Malaysia

YEAR	Population (million)	Motorcycle		Car	
		Number	per 1000 persons	Number	Per 1000 persons
1998	22.18	4,692,183	212	3,452,853	156
1999	22.71	5,082,473	224	3,787,047	167
2000	23.49	5,356,604	228	4,145,982	176
2001	24.53	5,609,351	229	4,557,992	186

In Vietnam, motorcycle is the major mode in traffic stream and makes up 90% of the traffic composition. Motorcycle ownership has undergone a drastic growth in recent years. Streets in urban area are full of motorcycle, especially during peak hour. Naturally, the car traffic is very low. In terms of modal share, the second biggest modal share is bus, followed by bicycles. The motorcycle ownership per thousand persons is 107. Comparing with the car traffic, the motorcycle has significantly more ownership than car. The growth rate of motorcycle ownership was 29.61% for the year 2000, whereas the car ownership only grew at the rate of 9.61%. The rapid increase in motorcycle ownership is in parallel with the equally rapid growth in the country's economy, and exemplifies the fact that Vietnamese prefer the motorcycle for mobility to support the economic development. The affordability of the motorcycles is also important, as majority of motorcycles on the road are the cheaper types. With such high number of motorcycles on the road, Vietnamese city centers are facing serious air and noise pollution problems. At present, despite motorcycles dominating the modal share, Vietnam, on the average only has about 11 motorcycles per thousand persons, as shown in Table 8. Comparing to Taiwan and Malaysia, the motorcycle ownership is set to continue to grow in the future.

Table 8: Car and Motorcycle ownership per 1000 persons of Vietnam

year	car	motorcycle	Car per 1000 persons	Motorcycle 1000 persons
1990	246,194	1,209,463	0.4	1.8
1991	256,898	1,522,184	0.4	2.3
1992	270,036	1,704,225	0.4	2.5
1993	292,899	2,427,163	0.4	3.5
1994	307,078	3,052,847	0.4	4.3
1995	340,779	3,578,156	0.5	5.0
1996	386,976	4,208,247	0.5	5.8
1997	417,768	4,827,218	0.6	6.5
1998	443,000	5,200,000	0.6	6.9
1999	456,000	5,600,000	0.6	7.3
2000	486,000	6,478,000	0.6	8.3
2001	532,681	8,395,835	0.7	11

CHAPTER 4. Motorcycle Usage and Mixed Traffic Flow

4.1 Motorcycle usage and trip purpose

In parallel with the high motorcycle ownership, it is expected that motorcycles are the main commuting mode for daily travel in these three countries. This situation is quite different from western countries, where motorcycles are primarily used for recreational purpose. Table 9 shows the information on trip purpose, while Table 10 shows the trip purpose for motorcycle user in Taiwan.

Table 9: Trip purpose percentage of motorcycle trip in Taiwan (MOTC, Taiwan, 2002)

Trip purpose	Total	Commuting	School	Working tool	Pick-up child	Shopping	Recreation	Other
1997	100	50.0	5.7	12.6	5.9	12.8	8.9	4.2
1999	100	49.2	6.2	10.7	8.1	16.1	6.1	3.4
2001	100	47.7	6.8	10.6	6.6	19.2	4.9	4.2

Table10: Trip type percentage of motorcycle usage in Taipei in 2001 (Taipei, 2002)

Mode	Home Based Work	Home Based Education	Home Based Other	Non Home Based	Average
Car	35	10	25	31	29
Motorcycle	33	19	33	35	32
Mass Transit	26	69	29	23	31
Taxi	6	2	13	11	8
Total	100	100	100	100	100

Although there is no detail survey result of motorcycle usage in Malaysia and Vietnam, through observation and experience, majority of motorcycle trips are for commuting needs. According to the survey result in Taiwan, the number of female user is increasing and getting more percentage of the gender split for motorcyclists in recent years, as shown in Table 11. The female user of motorcycle in Malaysia and Vietnam is still very small to be significant.

Table 11: Female and male motorcycle proportion in Taiwan (MOTC, Taiwan, 2002)

Year	1997	1999	2001
Male	62.4	59.4	57.8
Female	37.6	40.6	42.2
Total	100.0	100.0	100.0

4.2 Education level and multi-modal user

Another hypothesis on motorcycle usage is that it is related to the income and education levels; with people with lower education tend to use the motorcycle more. Table 12 illustrates the survey result in Taiwan (MOTC, Taiwan 2002). The value of A/B in Table 12 indicates the usage weight of the people with certain education level. If it has a value of more than one, more people in the particular group use motorcycles. The results show that the hypothesis may be supported in Taiwan, showing people with lower education level makes up the higher uses of motorcycle.

Table 12: Education level and motorcycle usage in Taiwan for the year 2001 (%)

Education level Of the population	Master and high	University & College	High school	Junior high school	Primary school and low	Total
Motorcycle usage percentage (A)	1.2	16.3	26.5	26.8	29.2	100
Percentage of the education to whole population (B)	2.5	32.2	34.1	16.2	15	100
A/B	0.46	0.51	0.78	1.66	1.944	

Most households in Taiwan have motorcycle and automobile at the same time and use them accordingly depending on the purpose of the journey and the time period the trip is made. About 68.4% of families with a motorcycle also own a car at the same time. More than 75% motorcycle-owning families have two or more motorcycle in the household. There is no detail study carried out in Malaysia and Vietnam for this information.

4.3 Income level and the age group using motorcycle

Income levels may influence the usage of motorcycle, and in general, a motorcycle is relatively cheaper and is often associated as the mode for the poorer people. However, the experience in Taiwan is not according to this assumption. About 70% of the families have a motorcycle and an automobile at the same time, despite a study showing that the average income level in Taiwan has decreased as shown in Table 13.

Table 13: Income level group of motorcycle user

Capita income per month (NT$)	Percentage (%)		
	1997	1999	2001
≤ 10,000	18.9	20.3	24.0
10,000~20,000	17.2	15.7	16.7
20,000~30,000	23.5	24.5	23.7
30,000~40,000	19.0	19.1	16.8
40,000~50,000	10.4	9.2	8.7
50,000~60,000	5.2	5.3	4.8
＞60,000	5.8	5.7	5.4
Total	100.0	100.0	100.0

Normally, a motorcycle is considered to be more appealing to the young people. However, such suggestion is not conclusive, as a study in Taiwan (Table 14) revealed that in the highest age group, the percentage using motorcycles is higher that that of a car.

Table 14: Age distribution of motorcycle riders and car driver in Taiwan

Age	Motorcycle user (2001)	Car driver (2000)
Under20	2.80%	0.20%
20 ~ 29	22.60%	13.70%
30 ~ 39	25.90%	35.80%
40 ~ 49	25.10%	31.60%
50 ~ 59	13.50%	13.90%
60 and over	10.10%	4.70%

4.4 Travel distance with motorcycle

Motorcycle is more suited for short distance travel and is not too suitable for long distance journey. The average travel distance using motorcycle in Taiwan is about 10.8 km, as shown in Fig.6. This distance range is also suitable for cycling and for using urban public transportation system.

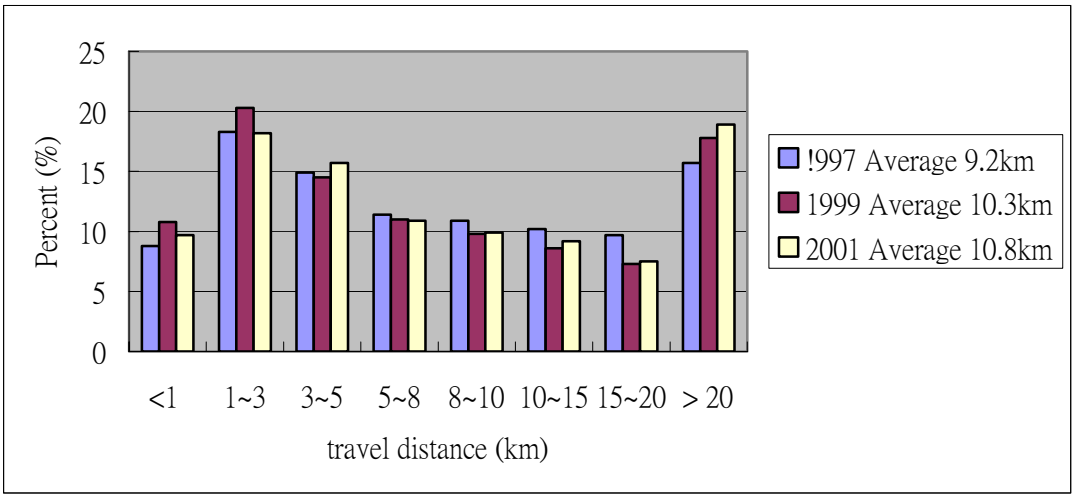

Figure 6: Motorcycle travel distance distribution in Taiwan

There are no such data In Malaysia and Vietnam. However, it is expected that the number of motorcycle users in the long distance is higher in Malaysia, and Vietnam, as their land area is bigger, and motorcycles need to have bigger coverage. This is also exemplified by the fact that motorcycles are allowed on the motorway and expressway, unlike the situation in Taiwan, where they are forbidden.

CHAPTER 5 Mixed Traffic Flow Characteristics

5.1 General characteristics

The traffic flow characteristics of motorcycle can be described microscopically as well as macroscopically. Microscopically, the motorcycle has two-dimensionally kinetic movement characteristics and is different from car movement. Motorcycles are normally used for commuting in an urban area. In Taiwan and in Vietnam the motorcycle traffic in urban area is significantly heavier than in rural area. In Malaysia, there is also significant usage of motorcycles in rural area. The composition of motorcycles in road traffic was also found to vary with road type and location.

5.2 Traffic composition of motorcycle

The mixed traffic characteristics can be described by the traffic composition of motorcycle, which is denoted as mixed rate α in Taiwan. It is equal to the number of motorcycles divided by the total amount of the traffic volume. The traffic composition of motorcycle varies from one place to another.

In Taiwan, the traffic composition in urban area is on the average 46% in Taipei and 57% in KaoHsiung, which is larger than that in the rural area, averaging 23% on provincial highways and 29% on local county rural highway (Hsu and Lin etc. 2002). During the peak hour, on the commuting corridor leading to urban centre, the motorcycle makes up the most significant composition of traffic, making more than 82% in Taipei metropolitan. To accommodate this situation, motorcycle exclusive lanes are build on the corridor bridges and on the main arterials in Taipei metropolitan. In Taiwan, motorcycles are not allowed to use the expressway and freeways; therefore, on the arterial corridors, the traffic composition of motorcycle will become higher.

According to a survey on the arterial connecting the outskirts to the city center of Taipei, the different locations have almost same traffic composition of motorcycle; indicating that many motorcycles drive from the outskirts to the city center. Even in the city, the motorcycle traffic composition will still be very high, as shown in Table 15. Some direction during the morning peak hour has a motorcycle traffic composition of more than 70%. An interesting observation is that next to this corridor arterial is the Tan-Shu MRT-line, and despite the high number of motorcyclist on the road, the MRT line is also full of passengers during the same time period.

Table 15: Traffic composition of motorcycle traffic volume in Taipei, Taiwan

Ta-Du Road and Chung-Yen Road Intersection (location on the suburban center)								
Bound Direction	Traffic volume (vph)				Traffic composition (%)			
	East	W.	S.	N.	East	W.	S	N
Large Vehicle	557	499	43	123	5.81	3.50	1.63	2.48
Car	5420	8901	447	3092	56.56	62.39	16.94	62.28
Motorcycle	3605	4867	2148	1750	37.62	34.11	81.43	35.25
Nan-King W. Road and Chen-De Road Intersection (location in the Taipei city center)								
Bound Direction	Traffic volume (vph)				Traffic composition (%)			
	East	W.	East	W.	East	W.	East	W.
Large Vehicle	447	400	382	477	7.58	4.31	3.74	5.13
Car	2680	2336	4504	3067	45.44	25.19	44.14	32.98
Motorcycle	2771	6539	5318	5756	46.98	70.50	52.12	61.89
Teng-Fei Ta Road and Pei-Shen Road Intersection (location on the outskirts)								
Bound Direction	Traffic volume (vph)				Traffic composition (%)			
	East	W.	S.	N.	East	W.	S.	N..
Large Vehicle	89	333	1253	208	4.61	9.25	23.80	4.41
Car	792	1511	2537	3136	41.06	41.98	48.19	66.54
Motorcycle	1048	1755	1475	1369	54.33	48.76	28.02	29.05

On the main corridors connecting the Taipei county to Taipei city, the traffic composition of motorcycle has more than 80% during morning peak hour, as shown in Table 16.

Table 16: Motorcycle traffic volume and composition on five corridors in Taipei

Period	AM Rush hour		PM Rush hour	
Mode	To the city	To the county	To the city	To the county
Motorcycle	123,308 (82.43%)	60,985 (73.64%)	80,299 (76.23%)	98,002 (81.14%)
Passenger Car	24,223 (16.19%)	19,876 (24.00%)	23,361 (22.18%)	20,993 (17.38%)
Commercial vehicle	2,066 (1.38%)	1,956 (2.36%)	1,676 (1.59%)	1,780 (1.48%)
Sum	149,597	82,817	105,336	120,775

In Malaysia, the traffic composition of motorcycle is not as high as in Taiwan. It makes up around 40% or urban roads, around 20% for commuting, except for commuters to Singapore, where 64.2% of traffic are motorcyclists on that corridor between Johor Bahru to Singapore. In rural areas, the traffic composition of motorcycles ranges between 25% AND 55%, depending on the locality. Table 17 illustrates this point (Ahmad, Wan and Radin, 2002).

Table 17: Traffic composition of motorcycle on the street in Malaysia

16 Hour Traffic Composition by samples of road type 1998 Data *(& 2000 Data)*

			Percentage Composition				
Road Type	Station	Linking	Car & Taxi	Small Van	Lorries	Buses	Motorcycle
URBAN TYPE	PR 202	Georgetown - Gelugor	46.7 *(50.4)*	3.9 *(3.4)*	2.7 *(2.9)*	5.9 *(4.6)*	40.8 *(38.6)*
SUBURBAN TYPE	WR 106	K. Lumpur - Petaling Jaya	72.3 *(73.2)*	6.3 *(8.0)*	2.0 *(2.4)*	0.4 *(0.4)*	19 *(16.1)*
	BR 807	K. Lumpur - Petaling Jaya	67.5 *(73.8)*	7.2 *(4.0)*	2.5 *(2.8)*	2.2 *(2.4)*	20.6 *(17.1)*
	JR 208	Johor Bahru - Singapore	24.1 *(24.6)*	1.6 *(1.70)*	3.5 *(3.2)*	6.6 *(7.1)*	64.2 *(63.3)*
INTERURBAN TYPE	AR 310	Ipoh - Bota	39.8 *(45.0)*	14.5 (14.7)	18.7 *(18.4)*	2.8 *(1.7)*	24.2 *(20.3)*
	PR 115	Butterworth - Taiping	44.1 *(42.6)*	8.8 *(10.0)*	14 *(14.6)*	4.3 *(3.7)*	28.8 *(29.0)*
RURAL TYPE	RR 102	Kangar - Pdg Besar	*(35.0)*	*(11.0)*	*(6.6)*	*(1.6)*	*(45.8)*
	CR 904	Kuantan - Rompin	*(38.7)*	*(11.5)*	*(24.8)*	*(1.1)*	*(23.8)*
	PR 115	Pasir Mas - Tanah Merah	*(26.0)*	*(1.3)*	*(9.3)*	*(8.6)*	*(54.8)*

In Vietnam, the traffic has motorcycle traffic composition of 80%. Especially in urban area, the street is full of the motorcycle. In such case, to design and manage the traffic using the concept of Passenger Car Unit will be seen as inappropriate. The truck in Vietnam has more traffic composition than car, as shown in Table 18.

Table 18: Traffic composition of the traffic in Vietnam

Location: Km 45+300, Highway No. 22 (AH1) *Date*: 25/08/2003												
Direction	Peak hour	Vehicle Type										Total
		Car		Bus		Truck		Trailer		Others		
		Veh.	%	Veh.	%	Veh.	%	Veh.	%	Veh.	%	Veh.
HCM City –Go Dau	AM	45	6.04	54	7.25	33	4.43	2	0.27	611	82.0	745
Go Dau – HCM City	AM	42	4.44	44	4.65	39	4.12	0	0	821	86.8	946
Location: Km 657+100 Highway No. 1A *Date*: 02/08/2003												
North - South	AM	14	4.75	47	15.9	63	21.4	0	0	171	58.0	295
South - North	AM	11	3.1	55	15.5	69	19.4	0	0	220	62.0	355

5.3 Traffic volume of motorcycle

The traffic volume of motorcycle can be as high as 10,000 motorcycles per hour on the urban arterials. The peak feature of motorcycle will be more significant than the car traffic according to the traffic purpose and the survey result in the three countries.

Figures 7, 8 and 9 show the traffic volume on the arterial in Taipei city of Taiwan.

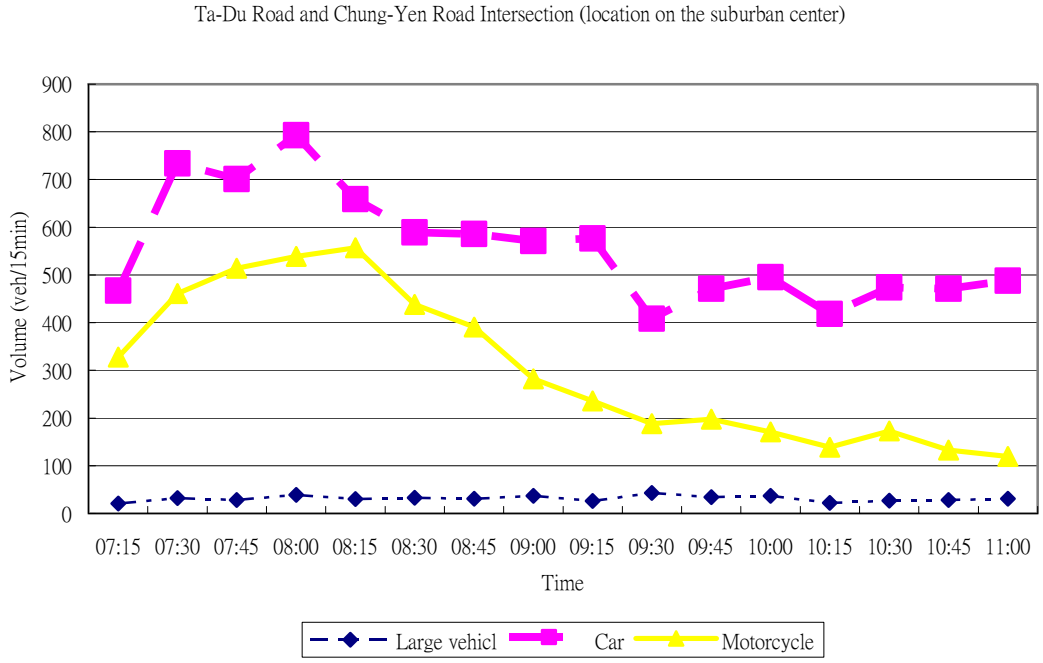

Figure 7: Motorcycle and traffic volume on the urban arterial in Taipei

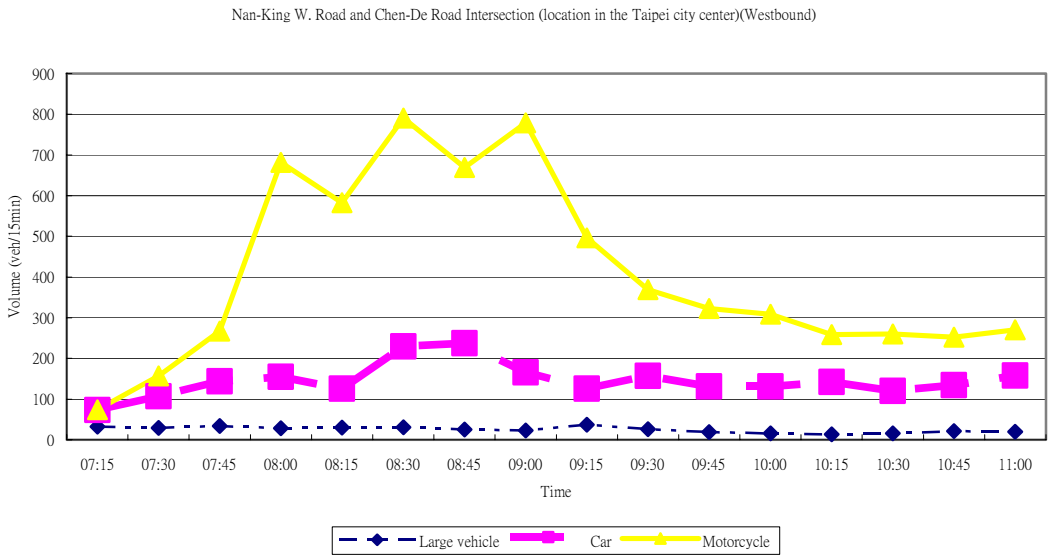

Figure 8: Motorcycle and traffic volume on the arterial in city center of Taipei

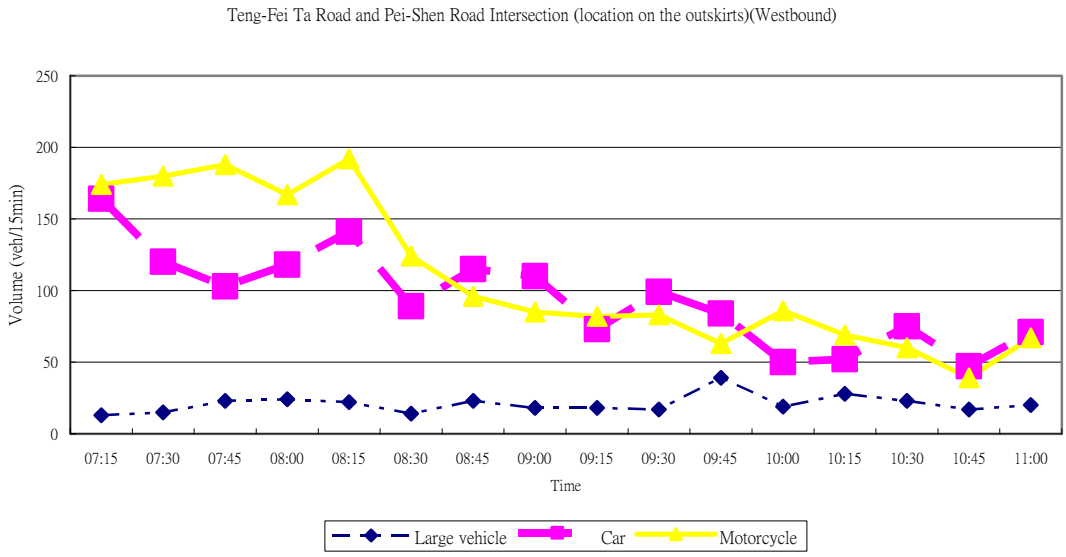

Figure 9: Motorcycle and traffic volume on the arterial in suburban of Taipei

The motorcycle traffic volume in Malaysia shows a different feature than Taiwan. There are several survey locations that have more car traffic volume than motorcycle, especially close to the city center. On the suburban or rural area, the motorcycle traffic will be higher than the car traffic.

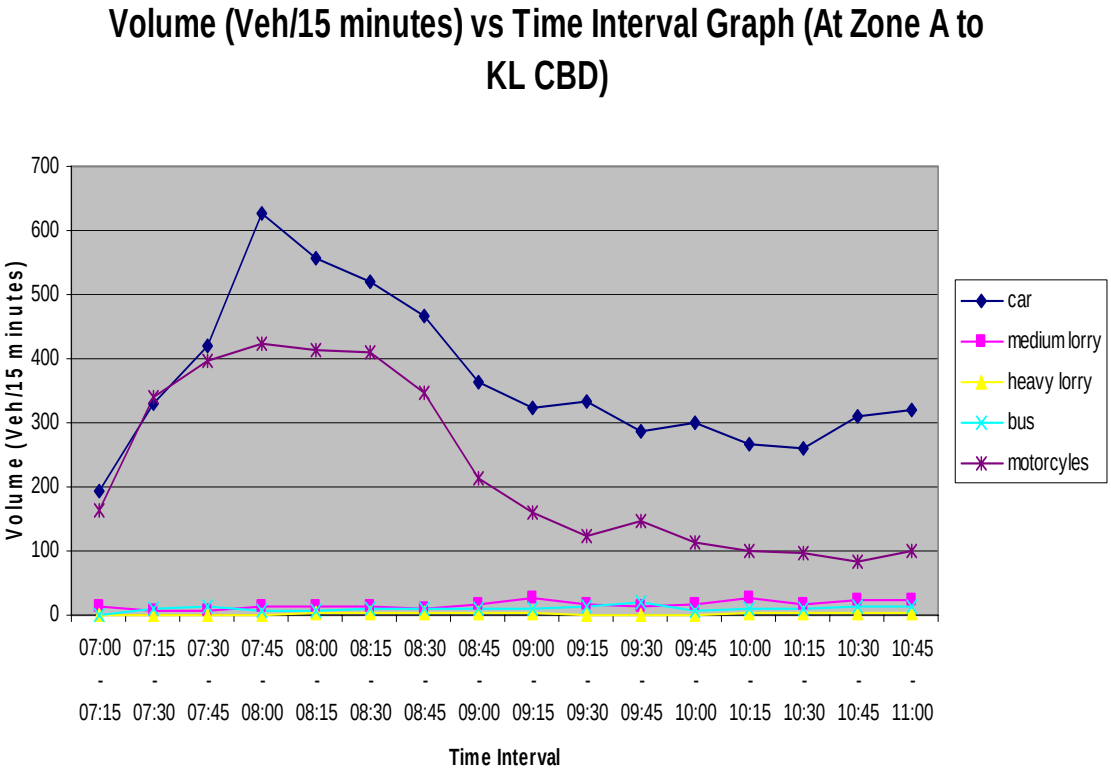

Figure 10: Traffic volume and motorcycle traffic in Malaysia

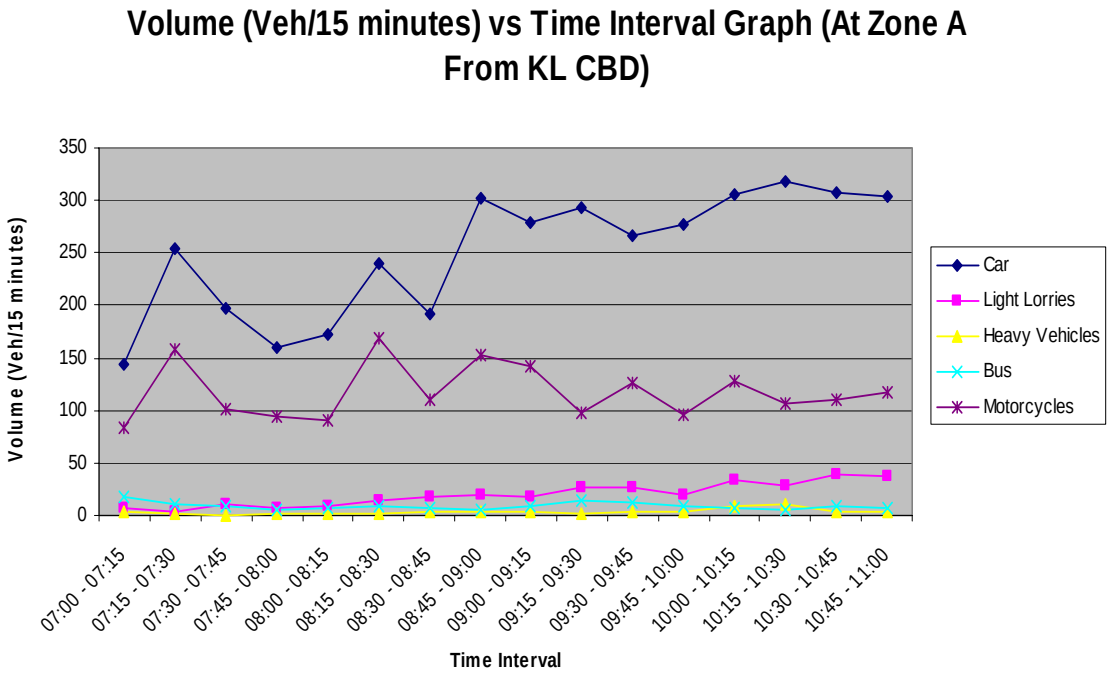

Figure 11: Traffic volume and motorcycle traffic in Malaysia

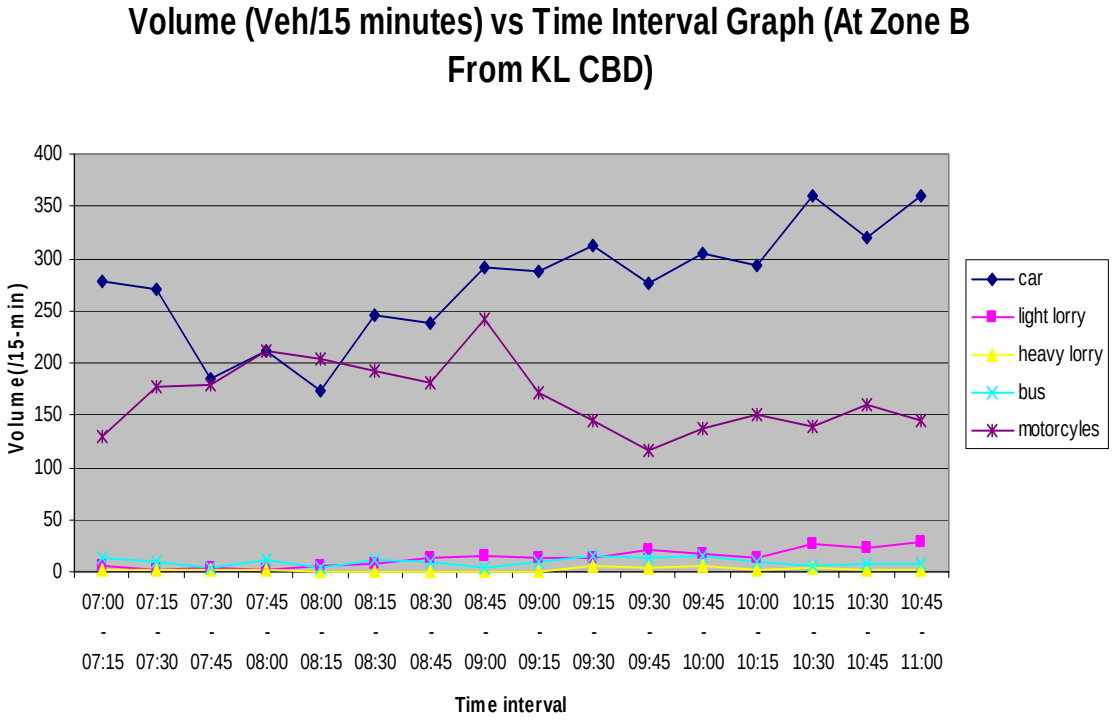

Figure 12: Traffic volume and motorcycle traffic in Malaysia

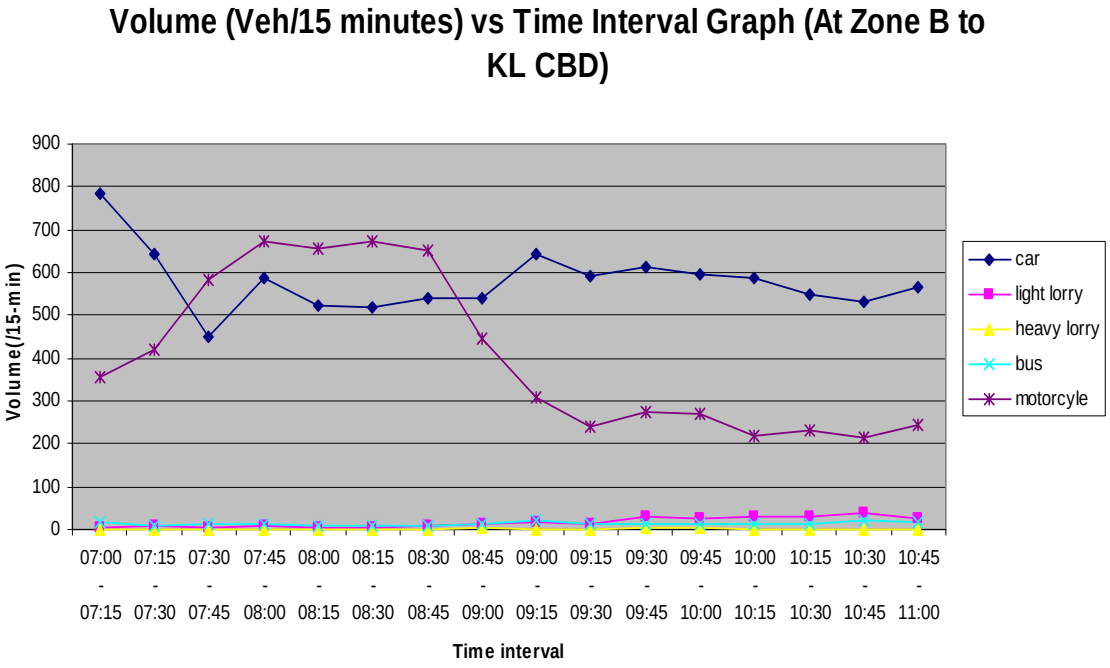

Figure 13: Traffic volume and motorcycle traffic in Malaysia

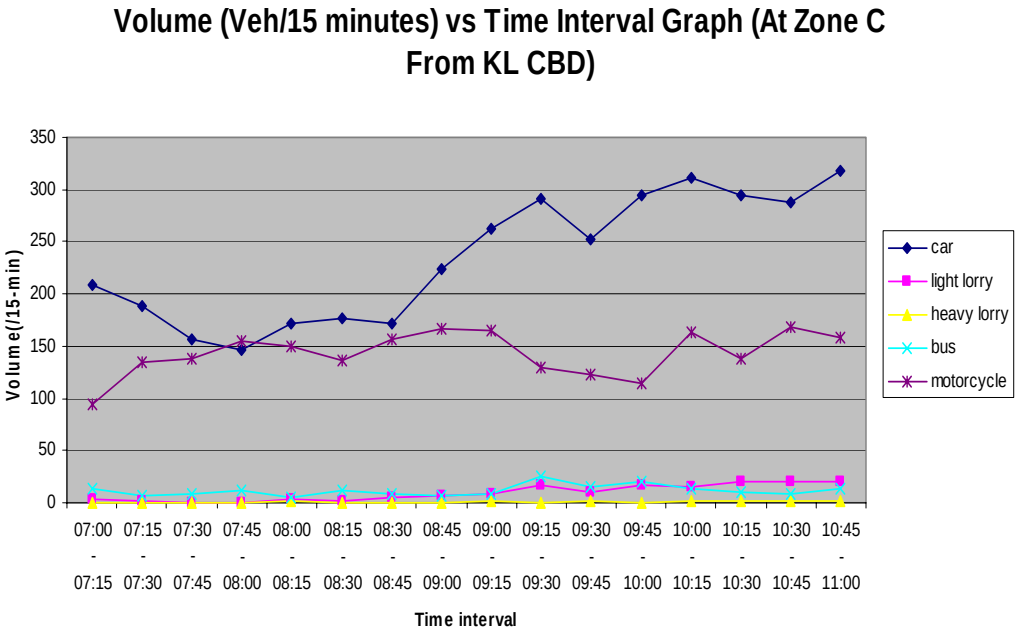

Figure 14: Traffic volume and motorcycle traffic in Malaysia

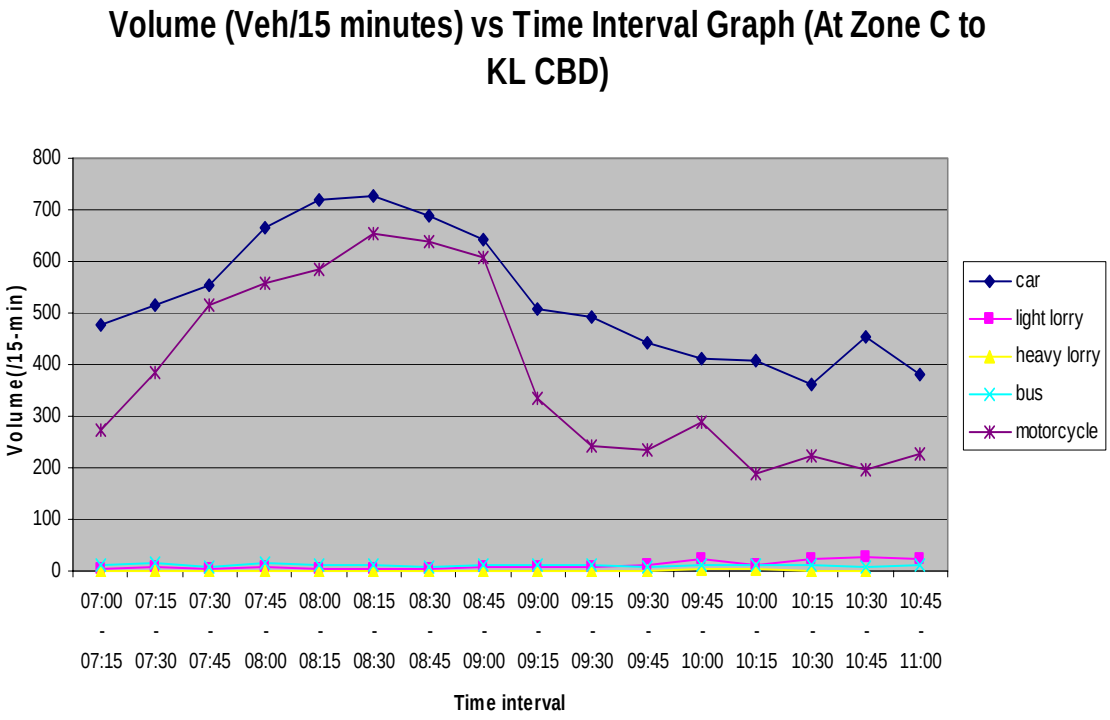

Figure 15: Traffic volume and motorcycle traffic in Malaysia

5.4. Travel speed by motorcycle

The motorcycle will have higher acceleration rate and shorter reaction time at the intersection by green time starting. The cruise speed of motorcycle is lower than the speed of car, therefore, the motorcycle platoon will be overtaken after a few minute departed from the stop line. Figure 16 illustrates the acceleration comparison of motorcycle with the car.

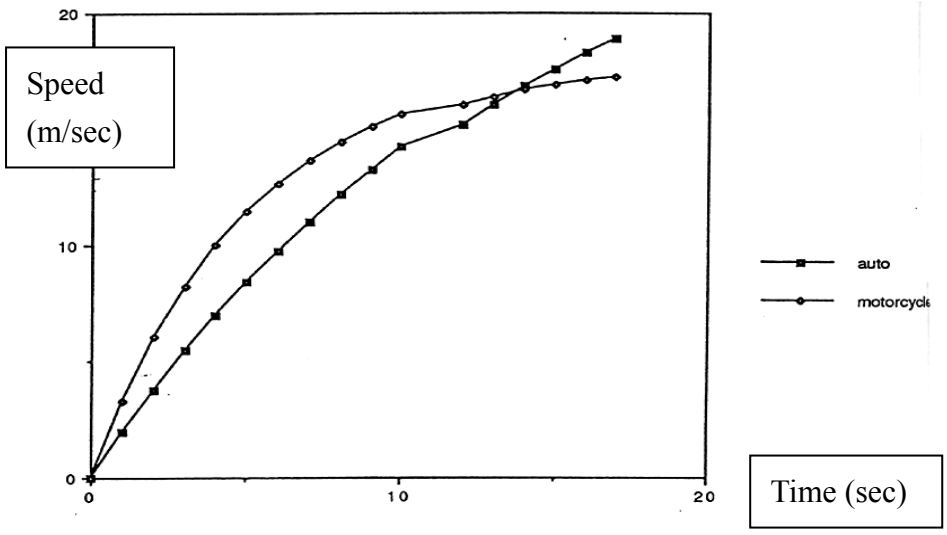

Figure 16: Cruise speed after starting of motorcycle and automobile

Normally, in the local alley and small streets the motorcycle can drive more quickly than the car, as shown in Fig. 17. The data in figure 17 is collected on the local street small alley in Taipei.

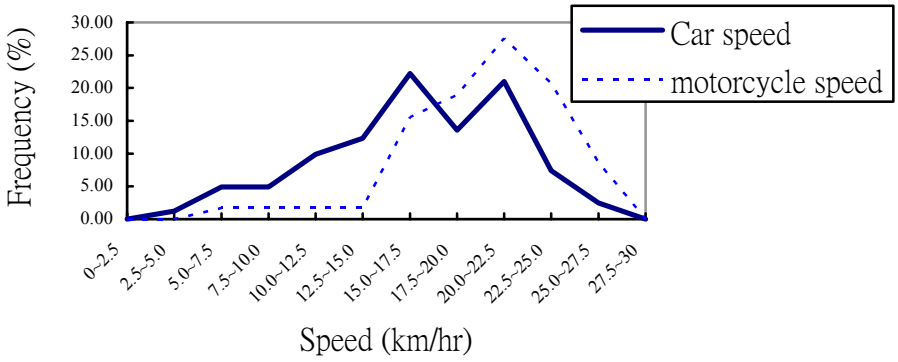

Figure 17: Speed distribution of motorcycle and car on local streets

5.5. Lane use distribution for motorcycles

Normally, the motorcycle will drive on the sideline in prevailing high motorcycle volume due to the safety reason. However, if there is not any regulation, the motorcycle will try to drive on the inside lane to overtake the automobile and cause the dangerous situation. To provide the motorcycle lane will also influence on the lane use of motorcycle. The Fig. 18 illustrates a survey result of the motorcycle exclusive lane before and after study.

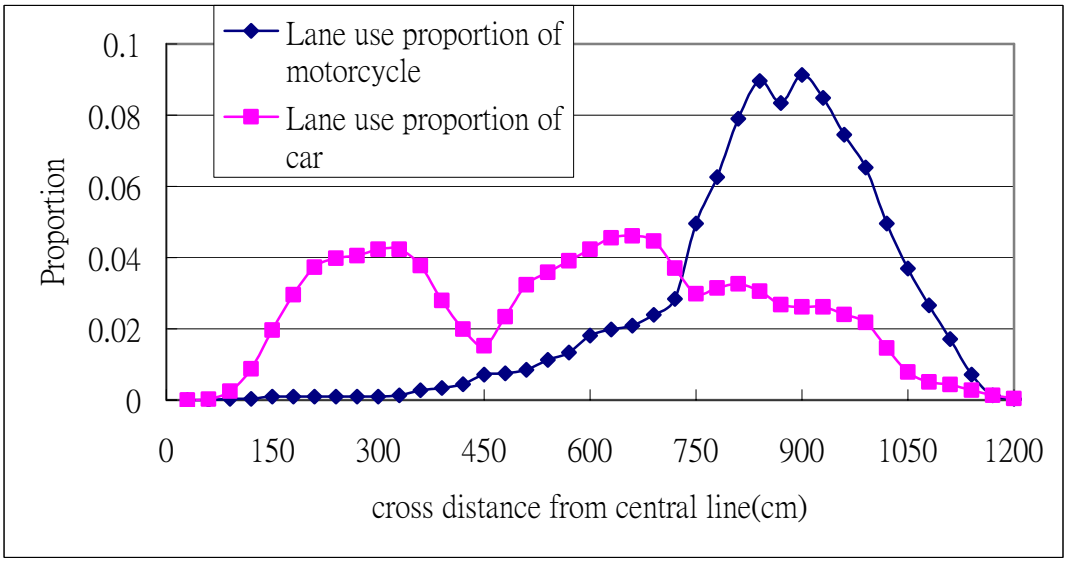

Figure 18: Lane use distribution of motorcycle and car without motorcycle exclusive lane

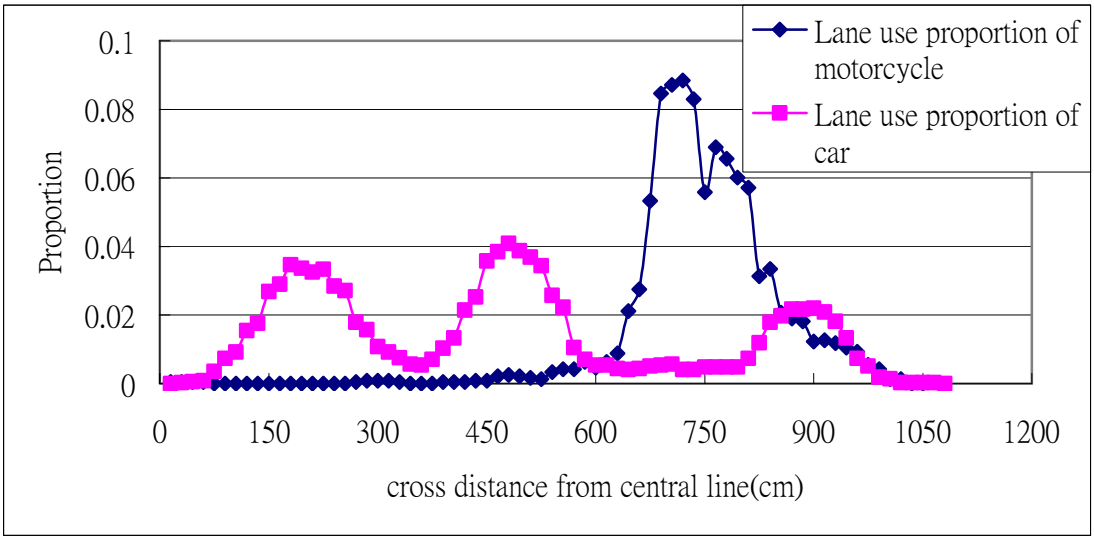

Figure 19: Lane use distribution of motorcycle and car with motorcycle exclusive lane

The motorcycle exclusive lane located in the city center of Taipei, is shown in Fig. 20.

Figure 20: Motorcycle exclusive lane in Taipei

5.6 Behavior at intersections

There are several distinct characteristics of motorcycles in traffic flow that may be identified, based on the field observation result in these three countries.

The motorcycle traffic flow on the road section:

- Motorcycle will normally drive on the side-lane of a street; the car will try to drive on the middle lane of a street (Hsu etc., 1995)
- The speed of a motorcycle in mid stream is usually lower than that of a car (Hsu etc., 1995)
- The noise made by an accelerating motorcycle is more than the car traffic (You, 1993).
- The mixture of motorcycle traffic will probably enhance the capacity of a street.
- The behavior of motorcycles in traffic stream is according to the car following and lane changing, as well as the side-by-side following and with overtaking behavior (Hsu, 1994).
- In Vietnam, streets are usually without a physical barrier to prevent driving onto the opposite direction.
- In Taiwan however, this phenomena can only be seen in local small alleys, especially when one-way regulation is imposed, the motorcycle will violate the rule by driving in the wrong direction.
- On rural highways in Taiwan, there is normally a shoulder-lane, which is commonly used by motorcycles, by which the safety of motorcycle can be enhanced. In Malaysia and Vietnam, the rural highway normally has no additional space for motorcycle; the overtaking of motorcycle by the car will cause more hazardous situation.
- In Taiwan, motorcycles are not allowed on freeways and expressways, while in Malaysia and Vietnam, they are allowed. The conflict between motorcycles and cars will again cause hazardous situations. However, in Malaysia, all expressways have shoulder lanes, and motorcycles often use them. Furthermore, motorcycle volume on expressways is low; therefore conflict in stream seldom occurs.
- Experience in Taiwan and Malaysia showed that by providing motorcycle exclusive lanes, the capacity and travel speed as well as safety performance of the whole street could be enhanced.

The motorcycle traffic flow at the intersection:

- Motorcycles will flock to the front of the traffic stream at intersections, and as a result many motorcycles will depart together within a very short time once the traffic signal turns green. This phenomenon will generate a motorcycle wave after the signalized intersection.
- Motorcycle will have negative starting delay (Hsu, 1982). Many motorcycles stop ahead of the stop line and will wait for the green phase on the pedestrian crosswalk. This situation may be found in all three countries.
- The acceleration rate of motorcycle is higher than car from stationery position, but less than that of cars when driving above 40 kph (Wu, 1983).
- The saturation flow of motorcycle is dependent on their queuing behavior near the stop line (Hsu, 1996). Because of the swarming departure phenomenon of motorcycle at intersection, providing the reserved head-start area for motorcycle may enhance the capacity of signalized intersections.
- In Vietnam, due to the high density of motorcycle, their non-signalized intersections are often saturated with motorcycles.
- In Taiwan, a two-stage rule maneuver has been imposed for left-turning motorcycles. No such rules have been introduced in Malaysia and in Vietnam. This rule will reduce the performance of motorcycle traffic and reduce the capacity of the intersection.
- In Taiwan, the cycle length is relatively longer in order to enhance the intersection capacity for car traffic. Therefore, the cycle length and green time is normally too long for motorcycle. However, the cycle length in Vietnam is normally shorter to accommodate the dominant motorcycle traffic, and may not be optimized for car traffic.

From field observations on the driving behavior of motorcycles, varying driving characteristics were observed amongst these three countries.

- In Taiwan and Malaysia, the motorcycle will normally drive on the lane nearest to the curbside, while cars will drive on the middle lanes of the street. In Vietnam, probably due to the shear volume of motorcycles, they practically drive everywhere across the street. The situation is made worst, as there is no regulation to control lane-discipline for motorcycles in Vietnam.
- In Vietnam, motorcycles often make a u-turn crossing the street and subsequently generate conflict with traffic from the other direction. This movement is not allowed in Taiwan and Malaysia, except at designated location. Furthermore, it is rather difficult for motorcycles to make a u-turn due to the heavy car traffic in Taiwan and Malaysia.

- In Vietnam and Taiwan, motorcycles often park on the sidewalk. In Malaysia, this situation is not so, as most motorcycles park on the curbside pavement.
- The shear volume of motorcycles and its disorderly movement in Vietnam resulted in many motorcycles using their horn while driving. Motorcycles in Taiwan and in Malaysia do not use horn often during driving.
- As indicated earlier, motorcycles have negative starting delay at signalized intersections in these three countries. However, motorcycles in Taiwan and in Malaysia will normally follow the signal, but with relatively earlier starting over other traffic. However, in Vietnam, motorcycles will fill the intersection and often do not follow the rule of the stop line.

5.7 PCE of motorcycle

Based on a car-oriented road design, motorcycle traffic volume is often calculated based on the number of Passenger Car Unit (PCU) using the Passenger Car Equivalent (PCE). The PCE adopted in Malaysia is 0.75 for roundabout design and 0.33 for signal design (Ahmad, etc., 2000), and in Vietnam is 0.5 (Dao, etc., 2002). In Taiwan, normally, the value 0.33 is officially adopted for transportation engineering, even though it would be dependent on the mixed rate α of motorcycle. The PCE of motorcycle could become less with high motorcycle traffic composition (Yen, 1987). PCE values of motorcycle were found to be dependent on the layout and the width of the street, as shown in Table 19. If the motorcycle traffic composition in a traffic stream is higher than 85%, to calculate the motorcycle volume based on a passenger car equivalent index will not make much sense; it is probably best to change the calculation approach by basing the car volume on a motorcycle-based index (so called motorcycle equivalent) (Hsu, 1982).

Table 19: PCE of motorcycle and the lane width

Width of lane Mixed rate of motorcycle	≦2.5	2.6 – 3.0	3.1 - 3.5	3.6 - 4.0	≧4.1
0.0 -0.25	0.3	0.25	0.20	0.15	0.10
0.26 - 0.50	0.25	0.20	0.15	0.10	0.05
0.51 - 0.75	0.20	0.15	0.10	0.05	0
0.76 - 1.0	0.15	0.1	0.05	0	0

Research in Malaysia shows similar results, that the PCE of motorcycle will depend on the width, the motorcycle traffic volume and the area where motorcycles are being driven, as shown in Fig. 21.

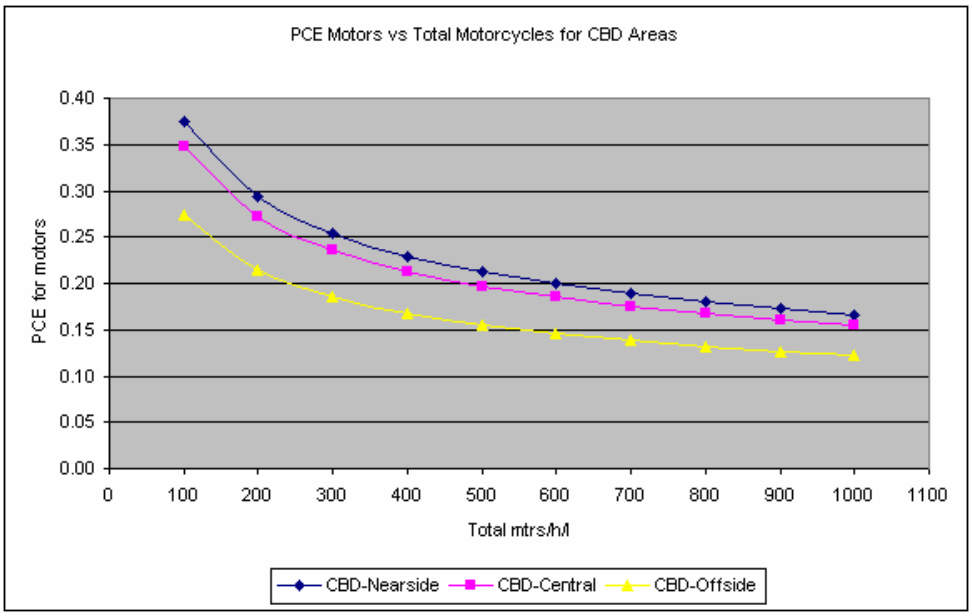

Figure 21: PCE value and the motorcycle volume on different location

CHAPTER 6. Safety

6.1 Accident data

Motorcycle is the most hazardous vehicle and may be proven by the accident statistics, especially in the developing countries (Lynam, et al., 2001). High motorcycle volume in developing countries, in addition to the intrinsic dangerous features of motorcycle traffic, especially, under mixed traffic situation contributes to the hazards associated with motorcycle traffic. Motorcycles were found to be the most hazardous mode in Taiwan, Malaysia and Vietnam. In Taiwan, motorcycles are involved in more than 50% of the total fatal accidents. Figure 22 and Table 20 show some accident statistics in Taiwan.

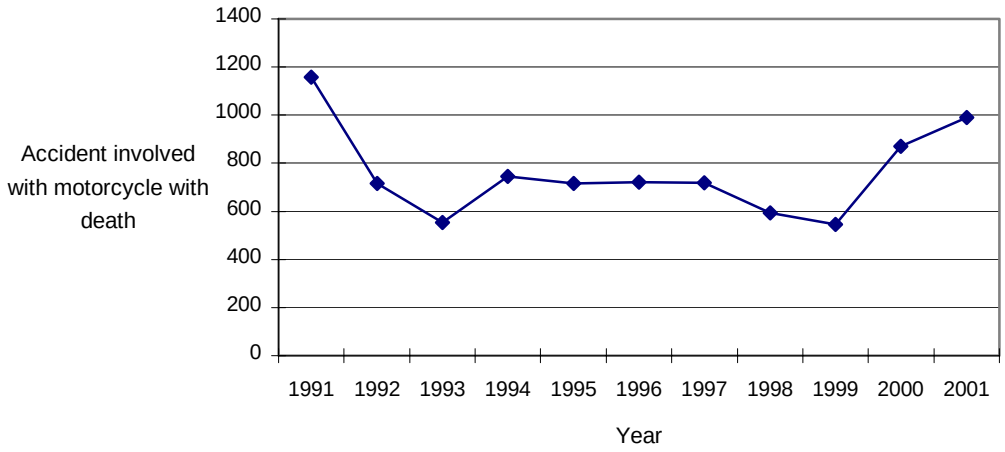

Figure 22: Fatal accidents involving motorcycles in Taiwan

Table 20 Motorcycle fatality accidents in Taiwan

	Motorcycle Traffic Accidents with death			The Percentage of Motorcycle Traffic Accidents in Total		
Year	Total accident (No.)	Dead (Person)	Wounded (Person)	Accident (%)	Dead (%)	Wounded (%)
1991	1159	1561	1820	24.5	47.2	41.6
1992	716	1195	1121	20.5	44.0	38.3
1993	554	1051	746	20.5	44.7	35.3
1994	746	1374	1006	20.7	44.4	34.3
1995	715	1313	912	20.3	42.8	31.1
1996	721	1318	1039	19.9	44.1	35.4
1997	719	1215	935	22.7	44.4	38.5
1998	593	1042	578	21.9	41.7	28.9
1999	545	1056	487	21.9	44.1	29.8

2000	870	1661	424	27.1	49.0	27.5
2001	990	1711	501	54.5	51.2	33.6

6.2 Accidents involving motorcycles in Taiwan

In Taiwan, motorcycle accidents occur frequently in daily traffic. Almost everyone has personally witnessed an accident involving motorcycles. According to the official statistic, fatality-involving motorcyclist contributes 51.2% of the total fatality in 2001, and resulted in 1711 death. In Taiwan, a fatal accident is termed so, if it results in death within 24 hours. Further studies on the accident data revealed that among the accidents involving motorcycles, the sideswiped collision has the most proportion, as illustrated in Table 21 (Hsu, 1997). This finding indicates that the frequency of motorcycle accidents on the road section in mid stream section of a road is higher than at intersections. As a result, motorcycle exclusive lanes to segregate motorcycles from other vehicles will be important to reduce the hazardous situation caused by motorcycle traffic. In Taiwan, motorcycle fatalities did decrease once in the year 1998, when the helmet wearing law was firstly implemented. However, thereafter, the fatality rate has increased again. The causing factors need to be identified.

Table 21: Collision type of motorcycle accidents (%)

Accident Type	Percentage
Right-angle collision	19.20%
Head-on collision	7.59%
Rear-end collision	8.04%
Sideswiped collision	38.84%
Pedestrian stuck by motorcycle	6.70%
Hole in roadway or fall down	3.12%
Collides with fixed object	5.80%
The other collision type	10.71%

6.3 Accidents involving motorcycles in Malaysia

In Malaysia, the annual statistics data shows that motorcyclists take up the highest proportion of involvement in accidents as well as the number of death due to the accident. Motorcycle involved accident has about half of the percentage of all accidents, as shown in Figure 23.

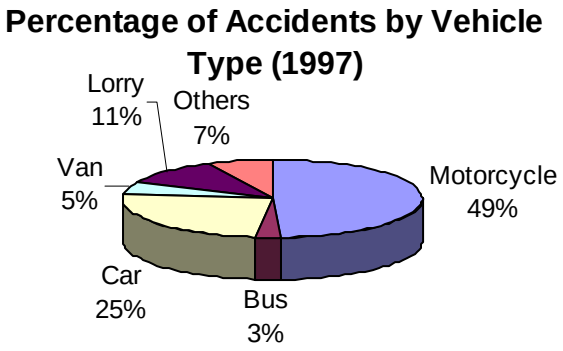

Figure.23: Percentage of accidents by vehicle type of Malaysia

In Malaysia, the motorcycle should have running headlight during all day. The motorcycle will weave around other vehicles and is often placed in the blind spot of other drivers. To make it be able to be seen, running headlight is taken as a safety improvement measure. According to the experience in segregating motorcycles from the main traffic stream by involvement of motorcycle exclusive lane since early seventies, the motorcycle lane has significant effect on reducing the motorcycle accidents of about 34% (Radin, etc., 2000). In Taiwan, the implementation of motorcycle exclusive lane resulted in similar positive effect to reduce motorcycle accidents. Furthermore, the total number of accidents on routes with motorcycle exclusive lane has also been significantly reduced. Table 22 shows some accident statistics from Malaysia.

Table 22: Total accidents on the road in Malaysia

Year	Registered Vehicles	No. of Vehicles Involved In Accidents	Total No. of Accidents	Fatal	Fatal Rate / 10,000 Vehicles
1990	5,462,792	146,747	87,999	4,048	7.41
1991	5,887,176	161,823	96,513	4,331	7.36
1992	6,263,383	193,421	118,554	4,557	7.28
1993	6,705,581	220,939	135,995	4,666	6.96
1994	7,210,089	251,766	148,801	5,159	7.16
1995	6,802,375	275,430	162,491	5,712	8.40
1996	7,686,684	325,915	189,109	6,304	8.20
1997	8,550,469	373,373	215,632	6,302	7.35
1998	9,141,357	366,932	211,037	5,744	6.28
1999	9,929,951	390,674	223,116	5,791	5.83
2000	10,548,121	441,386	250,417	6,035	5.72

Source：Ministry of Transport Malaysia (http://www.mot.gov.my)

6.4 Accidents involving motorcycles in Vietnam

In Vietnam, accidents involving motorcycles are huge due to the congested motorcycle traffic. Such accidents and the associated fatality have increased dramatically, especially, in the past two years. The year 2001 experienced a 39.66%, growth rate as shown in Table 23. This was primarily due to the economic boom during this period, and the associated growth in mobility needs. As a consequent, the number of motorcycles increased significantly during this period. Of the 25,040 accidents in Vietnam for the year 2001, 10,477 death and 29,188 injuries were resulted. And the accidents caused by motorcycles were 71.5% of the total. Because helmets are not compulsory in Vietnam, 88% of fatalities amongst motorcyclist were caused by head trauma. Vietnam has rather different accident characteristics. Many pedestrians collide with by motorcycles when crossing the street. There are also a lot of accidents caused by u-turning motorcycles. Head-on collisions between motorcycles also often occur. These types of collision can rarely be found in Taiwan or in Malaysia. Non-signalized intersections in Vietnam are one of the hazardous locations in Vietnam. Speed control and traffic regulation at intersections will be important to improve the safety problem.

Table 23: Fatality of accident and growth rate in Vietnam

Year	Number of Fatality	Growth rate %
1991	2 395	14.76%
1992	2 755	15.03%
1993	3 940	43.01%
1994	4 533	15.05%
1995	5 430	19.79%
1996	5 581	2.78%
1997	5 680	1.77%
1998	6 067	6.81%
1999	6 670	9.94%
2000	7 500	12.44%
2001	10 477	39.69%

In Vietnam, the number of fatality has increased very quickly during recent years, and may be associated with the equally rapid increase in number of motorcycle registration. The advantages provided by the high mobility of motorcycles, being

more affordable and the problems of parking in urban areas have made motorcycles more appealing to Vietnamese.

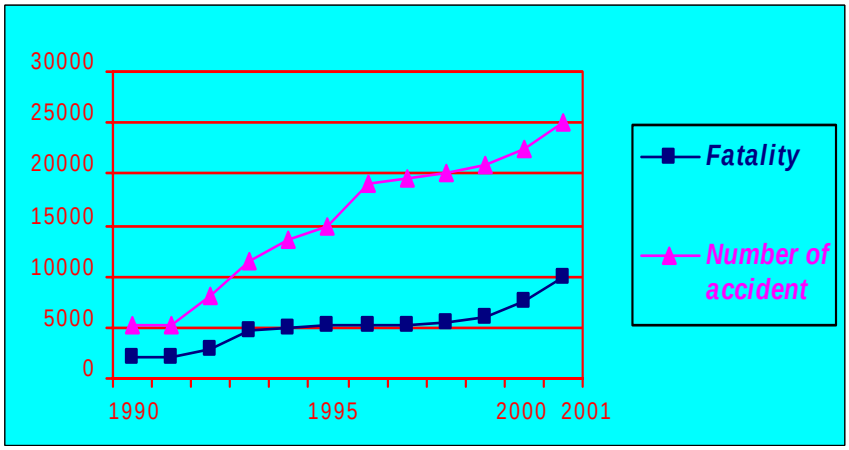

Figure 24: Fatality and accident of Vietnam

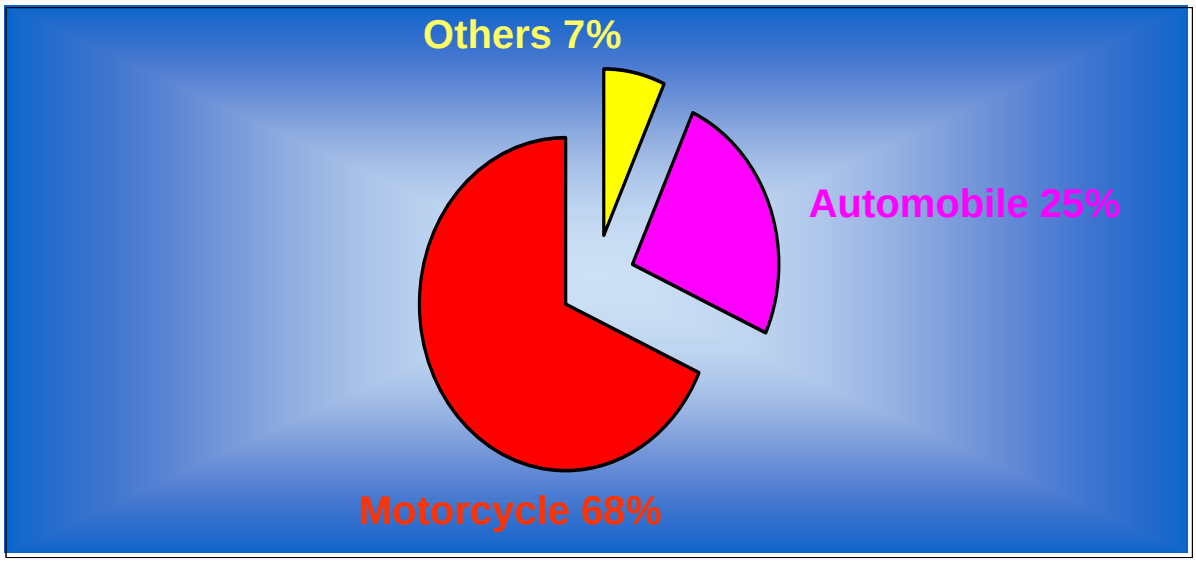

Figure 25: Traffic accidents by modes (data of 2000 - 2001)

In the year 2001, there were 25,040 road accidents with 10,477 fatalities and 29,188 injuries. Accidents caused by motorcycle contributed to 71.5% of total accidents, and in Hanoi, this number was up to 73%.

Further analysis on the accident statistics in Vietnam found the followings:

- Proportion of accident victims relating to motorcycle was 98%.
- Traffic accident injuries relating to motorcycle by gender: male 72.27%; female 27.73%.

- Traffic accident fatality relating to motorcycle by gender: male 78.02%; female 21.98%.
- Injuries in the age range between 16-45 are about 83% of total accidents, and 75% in terms of fatalities.
- Fatalities from head trauma due to motorcycle accidents were up to 88%.
- 60% of accidents happened between 1400 to 2200 hours.

Table 24: Fatal proportions of motorists relating to other transport means in Vietnam:

Relating transport means	Fatality proportions
Motorcycle	42.45
Automobile	17.94
Objects on roads (light posts, trees, median etc.)	13.20
Bicycle	9.43
Small trailer	5.74
Pedestrian	4.71
Car	2.84
Train	1.89

Further analysis on accidents involving motorcycles showed the following characteristics:

i) on the road section

- Accidents involving pedestrians occur at road sections where road crossings are made;
- Motorcycles often make U-turn suddenly and cause accidents
- Head-on collisions between motorcycles and motorcycles, and with other vehicles occur mainly in streets due to the absence of medians between two directions.
- Accidents happened when too many overtaking maneuvers happen, regardless of the vehicles.

ii) at intersections

- In absence of traffic signal, and proper traffic management schemes, mid-intersection accidents often happen.

iii) In crossings between roads and railway

- Accidents also often happen when many motorcyclists try to pass the safety barriers for railways.

CHAPTER 7 Guideline of Motorcycle Traffic Countermeasure

Conventionally, motorcycle is usually considered as another transport mode in a traffic stream and as a proportion of automobile using the Passenger Car Equivalence (PCE) concept to treat it. This may have led to the general tendency for authorities or even transport practitioners to ignore the motorcycle traffic and its impact to general traffic flow. One different view is to design and manage a mixed-traffic situation with heavy motorcycle traffic the viewpoint of the motorcycles. The problems contributed by heavy motorcycle traffic are becoming increasingly serious in the Asian countries. Thus, the motorcycle issues ought to warrant more serious attention by transport professionals in Asian countries.

In recent years, there have been many treatment trials for motorcycle traffic. Cases in point are illustrated for problems in Taiwan and are illustrated in Table 25. Such cases accumulated experience and thought the authorities in Taiwan, many lessons that may also be learned in other Asian countries. A new concept of segregating traffic was introduced, as part of the learning process, and Figure 26 shows the structure of the new concept. This new concept aims to change the driving space and traffic situation for motorcycles, in contrast to the previous approach. In addition to investigating the PCE and understanding its capacity issue, it is also important to provide better driving environment for motorcycles. Providing a traffic management concept to segregate flow and to put equal consideration in designing and analyzing traffic facility not only from the viewpoint of automobile, but also from the perspective of the motorcycles is also essential.

Table 25: Motorcycle traffic management introduced in recent years in Taiwan.

Time	Countermeasure	Location	Comments
1984	Set-up two stage left turn regulation	Taipei	Now spread to the whole country
1997.6	Helmet wearing duty	whole country	with extreme enforcement
1997.9	Head start waiting zone at the stop line	at three locations in Taipei	Now, to the whole country
1999.2	Trials the new design of motorcycle exclusive lane in city center	Taipei	a new era of motorcycle begins thereafter, and pro- mote to the whole with two types of motorcycle lane – exclusive lane and priority lane
1999.12	No parking of motor-cycle on the sidewalk	Taipei	Redesign the sidewalk with motorcycle parking bay, begin in Oct. 2000.
2002.3	Enforcement against violating motorcycle	whole country	on 15 motorcycle easily violating items
2002.7	Change the motorcycle classification to four classes	whole country	In the past, more than 150cc motorcycle is prohibited in Taiwan. Now is open due to WTO.
2002.7	Trial the running headlight of motorcycle all the day	Part of road sections in Taipei area	

The development of motorcycle traffic in Malaysia has also received greater attention. Developments concerning motorcycle traffic in Malaysia were:

- 1970s – introduction of safety helmets
- 1970s – first exclusive motorcycle lane in the world
- 1990s – motorcycles have to have their headlights on during the day
- 2003 – road tax abolished for all motorcycles below 150 cc.

The motorcycle issue is included in the recent research project to formulate a Highway Capacity Manual for Malaysia. The capacity analysis and PCE value determination of motorcycles is one of the main parts of this research.

In Vietnam, efforts are being made to treat the extraordinary traffic situation where majority of the traffic stream is made up of motorcycles. The street layout

concept and traffic control should be created especially for themselves and off course such a drastic concept will require more resources and commitment from the authorities.

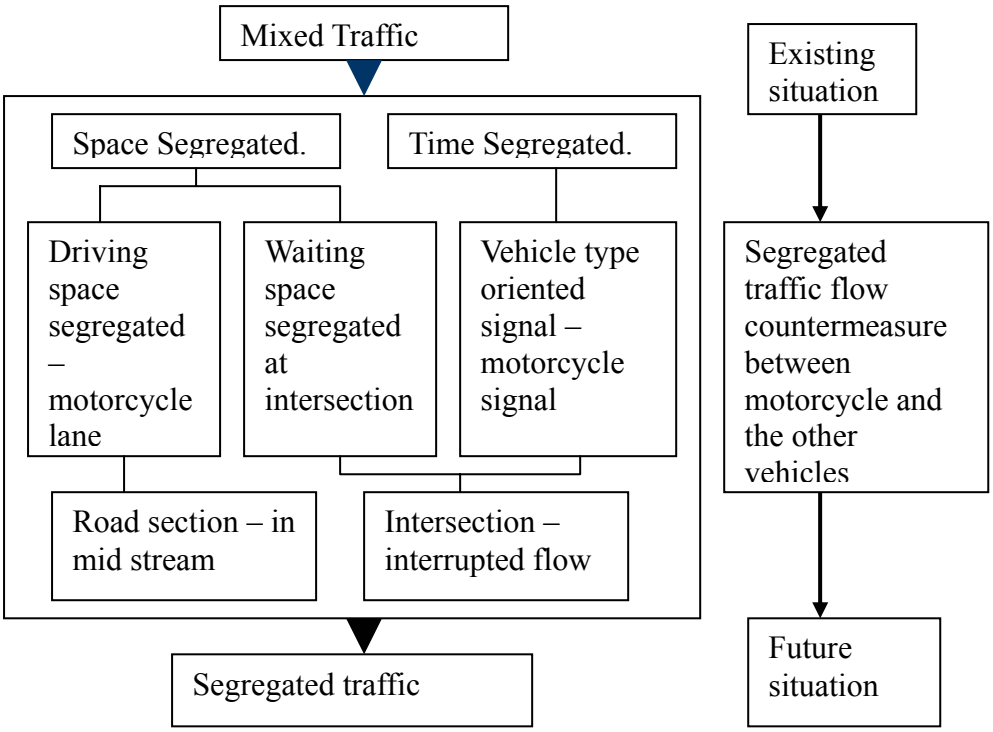

Figure 26: The concept structure from mixed traffic to segregated traffic (Hsu, 1997)

In general, the possible solution is to create a Guideline for Motorcycle Traffic. The guideline should discuss the following issues:

- Nature of motorcycle travel demand and perspective for future development and role of motorcycle in the traffic system
- The strategies and countermeasure to compromise the conflict between mobility and safety related to the motorcycle traffic.
- Development of planning concept and methodology for traffic system with mixed and segregated motorcycle traffic flow concept and design guide
- Traffic management strategies and design methodology for motorcycle traffic.
- Development of the capacity estimation and performance evaluation method for mixed and/or segregated motorcycle traffic.

For treating the motorcycle traffic problems, the advantage of using motorcycle should be recognized, and the reality of the demand of motorcycle should be considered. To solve existing problem and enhance the traffic performance will be the

first task. However, to reduce the dependence on motorcycle, furthermore on individual vehicle, and turning to public transport will be promoted continuously.

CHAPTER 8. Conclusions and Remark

Different countries have different development stages and different needs of traffic mobility. However, enhancing traffic safety and to ensure fluid traffic mobility will be the common objective. According to the experience in treating motorcycle problems, there are many issues that have not been considered and remain unclear from the scientific viewpoint of some Asian countries.

Motorcycle is getting significant attention as it is already and will be an important mode in the future. The motorcycle has its own advantage of less space needed for driving and parking compared to other vehicles. Furthermore, a motorcycle costs relatively lower. However, motorcycle is a hazardous mode, and therefore requires more effort to enhance their safety. An international cooperation for experience exchange is needed to understand the motorcycle travel demand behavior, and the traffic safety requirement.

The mixed traffic versus segregated traffic will be an issue in the future. A general Guide for Motorcycle Traffic is expected to collect the experience and to create the countermeasure for enhancing the traffic performance of the traffic system with motorcycle. More research efforts should be given for this purpose in the future.

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