ADB

Vulnerable Road Users

in the Asian and Pacific Region

Asian Development Bank

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The RETA project was undertaken by the following team under Charles Melhuish, Senior Policy Specialist, ADB. Those asterisked (*) were the major contributors to this volume. The project team comprised Alan Ross* (project director), Mike Goodge*, Caroline Ghee, Chris Robson, Tim Selby*, and Kim Smith of Ross Silcock Ltd.; and Amy Aeron-Thomas*, Chris Baguley, and Goff Jacobs of TRL Overseas Centre.

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Support was also received from a steering group comprising representatives of funding agencies, international organizations, technical groups, and individual experts from developing countries. They are as follows: John Flora of the World Bank, Alamgir Mojibul Hoque of Bangladesh, Ian Johnston of the Road Engineering Association of Asia and Australasia (REAAA), Charles Melhuish of ADB, M. Rahmatullah of UN/ESCAP, and C. Romer of the World Health Organization (WHO).

Thanks should go also to Graham Dwyer who edited the book and was responsible for much of its design work and production.

Acronyms

ADB	-	Asian Development Bank
CARS	-	Conference on Asian Road Safety
CSIR	-	Centre for Scientific and Industrial Research
CTEP	-	Calcutta Traffic Engineering Project (India)
DITS	-	Dhaka Integrated Traffic Study (Bangladesh)
Lao PDR	-	Lao People's Democratic Republic
MAAP	-	Microcomputer Accident Analysis Package
NIEs	-	newly industrialized economies
NMHC	-	national major highways of the People's Republic of China
NMV	-	nonmotorized vehicle
ODA	-	Overseas Development Administration (United Kingdom)
PDMCs	-	Pacific developing member countries (of the ADB)
PRC	-	People's Republic of China
RETA	-	regional technical assistance
SMV	-	slow moving vehicle
TRL	-	Transport Research Laboratory (United Kingdom)
TRR	-	*Transport Research Record*
UK	-	United Kingdom
UNDP		United Nations Development Programme
UN/ESCAP	-	United Nations Economic and Social Commission for Asia and the Pacific
US	-	United States
VRU	-	vulnerable road user

Measurements

km	-	kilometer
km/h	-	kilometer per hour
m	-	meter
mph	-	miles per hour
m/s	-	meters per second
ped/m^2	-	pedestrians per square meter
ped/min/m	-	pedestrians per minute per meter

Conversions

1 mph = 1.6 km/h
1 yard = 0.91 meter

CONTENTS

1 INTRODUCTION

1.1 ADB Regional Technical Assistance Project

This book on vulnerable road users (VRUs) has been produced as part of a regional technical assistance project (RETA 5620: Regional Initiatives in Road Safety) under Asian Development Bank (ADB) Contract No. 95-367. A companion book, *Road Safety Guidelines for the Asian and Pacific Region,* is intended as a source of reference and guidance to the region's senior decision makers with responsibility for road safety.

Analysis of available data shows that VRUs are involved in a high proportion of traffic accidents in some countries of the Asian and Pacific region. A specific effort was made to try to quantify the nature and scale of the road safety problems facing these road users and to

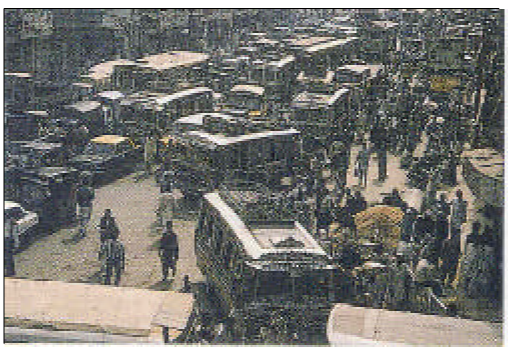


Plate 1.1 (above): Pedestrians exposed to risk in the traffic stream.

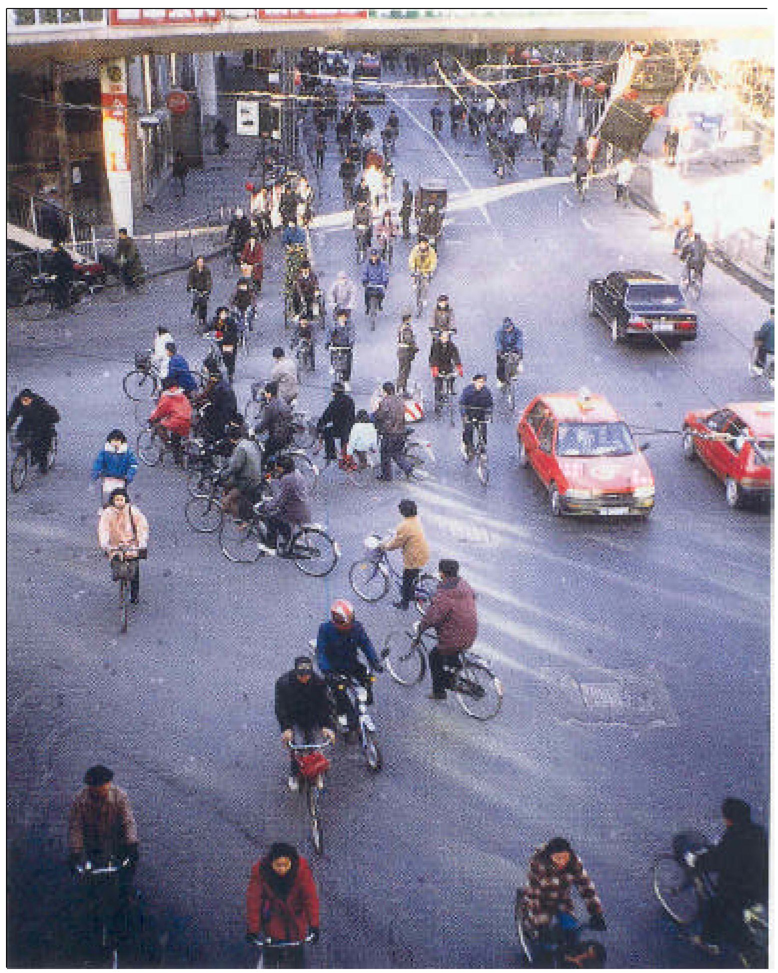


Plate 1.2 (right): Vehicles in conflict in the People's Republic of China (PRC).

Plate 1.3 (below): Typical cycle-rickshaw in Bangladesh.

identify examples of good practice in provision of safety facilities for this group. The definition of vulnerable road users varies depending on the context of a particular study. For the purpose of this volume, which addresses the needs of the Asian and Pacific region, the main focus is on:

1. pedestrians;
2. pedal cyclists and other nonmotorized vehicles; and
3. motorcyclists.

This publication has two main objectives, as follows:

i. to try to assess the involvement of VRU groups in Asia's high accident rate; and
ii. to identify and summarize general design considerations of VRU facilities in the region and, in particular, to identify successful innovative measures already in use.

Although the main focus of this publication is on current engineering practices, these measures in isolation do not necessarily solve all VRU safety problems. Consequently, complementary enforcement and educational measures are also briefly discussed. Because of the limited availability of detailed data, the publication is not always able to explore specific casualty types within each VRU group, such as the very young or very old, who may have a higher risk of being involved in accidents. The publication focuses most on pedestrian safety, as pedestrians are the road users at greatest risk in most countries, and considerable research and information was available for this group of VRUs. Serious efforts have been made to address pedestrian safety. By comparison, the review of facilities available for nonmotorized vehicles (NMVs) and motorcycles has been limited by the lack of attention given to them.

1.2 Structure

Following this introduction, Chapter 2 provides a general overview of the problems faced by VRUs. Chapters 3 to 5 consider the road safety situation for each VRU type and identify appropriate measures to assist each VRU.

The three main VRU modes discussed here have different operating capabilities, needs, and safety problems. Moreover, there has been much more research into pedestrian safety than NMV or motorcycle safety. Consequently, the chapters specific to VRU modes have taken different approaches. The pedestrian safety chapter has been able to review remedial measures specific to pedestrians in the region while the NMV chapter, of necessity, is restricted to information and observations that could be collected during the country visits, because little published information exists on NMV facilities.

For each VRU group, the collected data is presented according to six subregional groupings for the Asian and Pacific region. These are: the newly industrialized economies (NIEs), Central Asia, Southeast Asia, South Asia, Central Asian republics, and Pacific developing member countries (PDMCs). The countries within each of the subregion groups are as follows:

NIEs
Hong Kong, China; **Republic of Korea**; **Singapore;** and **Taipei,China;**

Central Asia
PRC and Mongolia;

Southeast Asia
Brunei, Cambodia, **Indonesia**, Lao People's Democratic Republic (Lao PDR), **Malaysia**, Myanmar**, Philippines**, **Thailand**, and **Viet Nam**;

South Asia
Afghanistan, **Bangladesh**, Bhutan, **India**, Maldives, **Nepal**, **Pakistan**, and **Sri Lanka;**

Central Asian republics
Armenia, Azerbaijan, **Kazakstan**, **Kyrgyz Republic**, Russian Federation, Tajikistan, Turkmenistan, Uzbekistan;

PDMCs
11 island nations including **Fiji**, **Papua New Guinea,** Samoa, and Tonga.

The countries shown in bold were visited by members of the project team in order to collect data, observe traffic conditions, and hold discussions with local safety specialists and researchers. A developed countries group (Australia, Japan, and New Zealand) has been included for comparison.

2 AN OVERVIEW

2.1 Introduction

Measures to assist VRUs through road design and traffic control methods have been recommended at various international conferences on traffic safety in order to recognize and reflect the special needs associated with these groups. Facilities suggested usually include segregating VRUs from motorized traffic and improving the urban environment through traffic calming techniques and pedestrianization. A recent such international conference held in New Delhi, India, on 27-30 January 1991 resulted in the Delhi Declaration on the safety of vulnerable road users. The recommendations and suggestions put forward in that and other such conferences are supported and expanded in this publication.

2.2 Pedestrians

In the 1970s, research conducted by the Transport Research Laboratory (TRL) of the United Kingdom (UK) identified pedestrian safety as a problem area for developing countries. Pedestrians, in general, are involved in more accidents in developing countries than in developed countries. While this can be partially explained by the low motorization levels in developing countries, traditional transport planning and traffic management have generally tended to focus on the safety of vehicular traffic and have largely overlooked pedestrians. In addition, there tends to be a higher percentage of pedestrian trips in the cities of the developing world due to the inaffordability of private transport and inadequate public transport.

Local conditions do influence pedestrian safety, as can be seen by casualty age and vehicle types involved. Developing countries have also been found, in general, to have a higher percentage of child pedestrian deaths than motorized countries. While this may be explained by the population distribution (developing countries tend to have a much higher percentage of children), remedial measures must be designed to reflect the target age group, its relative youth, and lack of maturity. Commercial vehicles have also been found to have high rates of involvement in pedestrian accidents in developing countries. While this may be due to their larger share of the vehicle fleet and increased exposure, remedial measures may need to be designed specifically to target professional drivers with little education or financial resources, and the transport operators and commercial vehicle owners who employ them.

2.3 Nonmotorized Vehicles

NMVs such as pedal cycles, cycle-rickshaws, animal carts, and handcarts have traditionally been an essential means of transporting people and goods in the cities and towns throughout the developing world, particularly in Asia. In recent years, however, they have come under an increasing threat that has led to their almost complete disappearance in some major cities in Asia (for example: Calcutta, **India**; and Jakarta, **Indonesia**). A study commissioned by the World Bank and carried out by PADECO Co., Ltd. in 1995 reports that the factors threatening the future of NMVs in Asian cities are as follows:

a) increased motorization (including the increased use of motorcycles) and a con-

sequent reduction in street space available for safe NMV use;

b) increased trip lengths caused by changes in metropolitan spatial structure;

c) exclusion of NMV needs in urban transport planning and investment programs, resulting in inadequate facilities for NMVs;

d) a general trend towards modernization of Asian cities that promotes attitudes that NMVs are “backward”;

e) a tendency to believe that NMVs are the cause of urban congestion; and

f) excessive and often inappropriate regulation of NMV operation, including limitations on NMV ownership and total or partial banning of their use.

Experience gained from visits to countries with high NMV usage during this RETA study and reported upon by Goodge and Selby during a safety seminar sponsored by the ADB and the United Nations Economic and Social Commission for Asia and the Pacific (UN/ESCAP) seminar in Bangkok in 1996 tends to confirm that these factors are operating throughout the region.

However, government roads and planning departments in a number of countries were observed to be providing, or are planning to provide, facilities specifically for NMVs, or in conjunction with other vehicles that may be defined as either slow or two-wheeled. These facilities provide significant potential for reducing safety and capacity problems.

All NMVs can be considered to be among the group generally termed “vulnerable road users.” However, this report will show that in many countries, their reported accident rates were observed to be relatively low, particularly when compared to the statistics for motorcycles and pedestrians.

An exception to the relatively low level of accidents involving cyclists occurs in certain cities in the **PRC**, such as Beijing, where cyclists are involved in about 70 percent of the total traffic accidents. In the PRC, cyclists generally constitute the largest proportion of the traffic flow in most cities.

Although data for the separate categories of NMVs have been included for the purposes of this report, it is recognized that pedal cycles, cycle-rickshaws, and other NMVs all display differing operating capabilities and thus have different associated problems. So it should be noted that any facility should take into account the expected NMV traffic composition during the design stage.

2.4 Motorcycles

Motorcycles account for a large proportion of all motor vehicles in some of the countries in the Asian and Pacific region. Due to their comparatively low cost, motorcycles tend to be the first affordable motor vehicles that can be purchased and used by young drivers. Unfortunately, these riders have high-risk thresholds, limited training and testing, and, obviously, a lack of experience, all of which contribute towards making them high-risk road users.

Unsurprisingly, accidents involving motorcycles tend to be greatest where large motorcycle fleets exist relative to the number of motor vehicles. The continued growth of this vulnerable motorized mode of transport may accelerate motorization and death rates in the region.

2.5 Data Overview

The extent of the VRU safety problem is primarily reviewed using data collected under a parallel UN/ESCAP study. However, data gathered from local officials during ADB RETA-related country visits, and from recent publications, have also been consolidated and is presented along with the UN/ESCAP data within the individual VRU chapters. The data gathered for NMVs as part of the UN/ESCAP study concentrate on cycle-based two- and three-wheeled vehicles.

Thus, pedal cycle and cycle-rickshaw data cannot generally be separated. However, from alternative sources, the proportional split of the NMV types has been shown wherever possible.

Accident data for the region are summarized in Tables 2.1 and 2.2, which show that pedestrians and motorcyclists are involved in the majority of fatal and injury traffic accidents. More than half of all fatal accidents in **Malaysia**; **Singapore**; and **Taipei**,**China** involve motorcyclists, while in **Hong Kong**, **China**, more than two thirds of all fatal accidents involve pedestrians.

From the data available to date, cyclists seem to be involved less frequently in reported

Table 2.1: Percentage of Fatal Accidents Involving Vulnerable Road Users (1993)				
Subregion	**Country**	**Pedestrian** (percent)	**Cycle-based vehicle**[1] (percent)	**Motorcycle** (percent)
NIEs	**Hong Kong, China**	67	4	10
	Republic of Korea	48	0	7
	Singapore	25	8	51
	Taipei,China	19	6[2]	64
Central Asia	**People's Republic of China** (1994)	11[2]	9[2]	10[2]
Southeast Asia	**Malaysia** (1994)	15[2]	6[2]	57[2]
	Thailand	9	4	na
South Asia	**Sri Lanka**	45	17	16
PDMCs	**Fiji**	43	3	1
Developed Countries	**Australia**	19	3	na
	New Zealand	15	3	16

na Data not available.
(1) Includes two- or three-wheeled cycle-based vehicles.
(2) Data relate to deaths.
Source: RETA project data.

Table 2.2: Percentage of Injury Accidents Involving Vulnerable Road Users (1993)				
Subregion	**Country**	**Pedestrian** (percent)	**Cycle-based vehicle**[1] (percent)	**Motorcycle** (percent)
NIEs	**Hong Kong, China**	35	4	17
	Republic of Korea	na	0[2]	6[2]
	Singapore	17	5	69
	Taipei,China	13	5	62
Central Asia	**People's Republic of China** (1994)	9[2]	na	74[2]
Southeast Asia	**Malaysia** (1994)	6[2]	5[2]	57[2]
South Asia	**Sri Lanka**	48	19	26
PDMCs	**Samoa**	37	6	9
Developed Countries	**Australia**	15	7	na
	New Zealand	9	9	14

na Data not available.
(1) Includes two- or three-wheeled cycle-based vehicles.
(2) Data relate to casualties, excluding deaths.
Source: RETA project data.

accidents than the other two groups of VRUs.

Table 2.3 shows the split between vehicle modes owned in selected cities throughout the region.

Although there are high percentages of motorcycles in certain cities such as Phnom Penh, **Cambodia**; Surabaya, **Indonesia**; and Chiang Mai, **Thailand**, it should be noted that there is still a high level of cycle ownership in many cities, including Surabaya, and (with the exception of Dhaka, **Bangladesh**) they are the most widely owned NMVs in those cities.

Table 2.3: Percentage of Total Vehicles (Not Including Handcarts) by Vehicle Type in Selected Asian Cities

City (Country)		Bicycle	Cycle-rickshaw	Animal cart	Bus	Motor-cycle	Other motor vehicle
Dhaka **(Bangladesh)**	(1990)	10.7	53.3	0.0	1.3	16.0	18.8
Phnom Penh **(Cambodia)**	* *	47.1	4.2	0.2	0.0	43.6	4.9
Shanghai **(People's Republic of China)**	(1990)	95.9	1.4	0.0	0.3	0.5	1.9
Kanpur **(India)**	(1992)	54.7	3.5	0.6	0.1	18.6	22.4
Surabaya **(Indonesia)**	(1992)	40.1	4.6	0.0	0.3	38.7	16.3
Tokyo **(Japan)**	(1992)	59.9	0.0	0.0	0.1	13.8	26.2
Penang **(Malaysia)**	(1992)	49.6	0.6	0.0	0.0	29.0	20.8
Metro Manila **(Philippines)**	*	12.6	0.7	0.0	0.7	8.4	77.6
Chiang Mai **(Thailand)**	(1992)	4.2	0.6	0.0	0.0	72.3	22.9
Hanoi **(Viet Nam)**	(1992)	84.6	0.4	0.0	0.0	10.8	4.12

(*) Unknown year of source.

Source: PADECO Co., Ltd., 1995.

3 PEDESTRIAN SAFETY

3.1 Introduction

Pedestrian safety in the Asian and Pacific region is first summarized by accident data before engineering facilities for pedestrian safety are reviewed. As the provision of facilities alone cannot guarantee appropriate usage and improved safety, this chapter closes with recommendations on how enforcement and education, and publicity campaigns can be organized to complement safety engineering efforts and to reinforce safe road user behavior.

Walking accounts for a significant share of all urban trips in developed countries (i.e., about a third of urban trips in the **UK**). But the inability to afford private transport and unavailability of public transport result in walking representing a much greater share of urban and rural trips in developing countries. While the lessons and experiences can be considered from developed countries, pedestrian safety programs in the developing world must reflect both the greater demand and the limited resources available to address pedestrian mobility and safety. Accordingly, the measures discussed here will focus on low cost, and thus low risk, facilities that can be afforded on a wide scale and are easily implemented.

3.2 Pedestrian Accident Data

In comparison with other road user groups, pedestrians are involved in a significant number of fatal and injury accidents in numerous countries in the Asian and Pacific region (see Tables 2.1 and 2.2).

Table 3.1 shows a comparison of these pedestrian accidents for various countries in the region. Overall, **Hong Kong, China** had the highest share of pedestrian deaths (two thirds of all fatal accidents), while pedestrians were involved in 62 percent of the total fatal accidents reported in Dhaka, **Bangladesh**, 48 percent in the **Republic of Korea**, 45 percent in **Sri Lanka,** and 43 percent in **Fiji**.

Malaysia (a country with a large motorcycle fleet) reported pedestrians involved in more

Plate 3.1: Incompatible mix of vehicles and pedestrians.

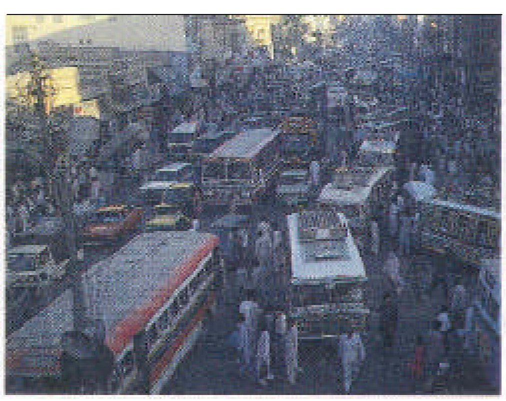


Plate 3.2 (far right): Pedestrians are often exposed to danger during construction work.

Table 3.1: Pedestrian Accidents as Percentage of Total Fatal and Injury Accidents

Subregion	Country	Year	Fatal accidents (percent)	Injury accidents (percent)
NIEs	**Hong Kong, China**	1993	67	35
	Republic of Korea	1993	48 (1)	na
	Singapore	1993	25	17
	Taipei,China	1993	19	13
Central Asia	**People's Republic of China**	1994	11 (1)	na
Southeast Asia	**Malaysia**	1994	15 (1)	9 (1)
	Thailand	1993	9	na
South Asia	Dhaka, **Bangladesh**	1996	62	32
	India	1991	2	2
	Nepal	1993	45 (1)	16 (1)
	Karachi, **Pakistan**	1993	50 (1)	na
	Sri Lanka	1993	45	48
PDMCs	**Fiji**	1993	43	na
	Papua New Guinea	1992	33 (1)	15 (1)
	Samoa	1993	50	37

na Data not available.
(1) Data relate to casualties.
Source: RETA project data.

than 20 percent of total accidents, while **India** and **Thailand** reported such an unlikely low level of pedestrian accident involvement that the data should be double-checked.

Table 3.2 shows that the majority of pedestrian casualties occurs among those of working age. In **Malaysia**, older teenagers (age 16-20) were the second largest pedestrian casualty group compared to **Fiji** and **Papua New Guinea,** where those under 15 were the second largest pedestrian casualty groups.

The pedestrian accident severity ratios, based upon the number of fatal accidents relative to injury accidents, vary widely, as shown in Table 3.3.

While high ratios are found in the urbanized economies of **Hong Kong, China;** and **Singapore,** the ratio for Dhaka, **Bangladesh,** was suspiciously low. **India's** ratio was also low compared to **Samoa** and **Sri Lanka**. The typical equivalent ratio in the **UK** is 46 pedestrian injury accidents reported for every one pedestrian fatal accident reported.

Too many countries are not yet able to even determine their pedestrian accident involvement rates.

Given these countries' low motorization levels, vulnerable walk trips are likely to dominate travel patterns, with pedestrians representing a large, if not the majority, share of road accident victims.

It is, therefore, highly likely that a significant amount of underreporting of VRU road accidents also occurs in developing countries. The severity ratios above imply that substantial numbers of pedestrian injury accidents are not

Table 3.2: Age Distribution of Pedestrian Casualties						
Age	**Fiji** (1992)		**Malaysia** (1994)		**Papua New Guinea** (1992)	
	Death (percent)	**Injury** (percent)	**Death** (percent)	**Injury** (percent)	**Death** (percent)	**Injury** (percent)
Under 15	16	10	11	10	24	16
16-20	7	14	21	24	9	13
21-60	67	63	58	62	65	70
Over 60	10	3	10	4	1	0

Source: RETA project data.

Table 3.3: Ratio of Pedestrian Fatal Accidents to Pedestrian Injury Accidents					
Dhaka, **Bangladesh** (1993)	**Hong Kong, China** (1993)	**India** (1991)	**Samoa** (1991)	**Singapore** (1993)	**Sri Lanka** (1993)
1:0.7	1:24	1:5	1:9	1:15	1:11

Source: RETA project data.

being reported in the accident data systems. (However, some of the difference may be explained by poorer emergency medical services, which would result in a higher proportion of victims dying in developing countries in comparison to those in developed countries.)

Available statistics have been analyzed for a number of countries and recent trends in pedestrian casualties are summarized (by country) below. It should be noted that in some cases, data are available only on the percentages of deaths while in other cases it is available only as a percentage of fatal accidents.

Although not directly comparable (a single traffic accident could cause several deaths), the data on percentage of fatalities or percentage of fatal accidents do give some idea of relative importance of pedestrian deaths.

a) NIEs

Hong Kong, China

67 percent fatal accidents,
35 percent injury accidents

In 1993, 336 road accidents involving deaths and more than 15,000 road injury accidents occurred in Hong Kong, China, with pedestrians involved in 224 fatal accidents and 5,281 injury accidents. Pedestrians accounted for two thirds of all fatalities. While the number of fatal accidents involving pedestrians has fluctuated over recent years, injury accidents declined by more than 15 percent between 1987 and 1993 to make up 35 percent of total injury accidents.

Republic of Korea

48 percent fatal accidents

In the Republic of Korea, pedestrians accounted for almost half of all road accident deaths in 1992 (5,542 of 11,640). This represented a small decrease from the previous year when pedestrian deaths amounted to 6,441 and comprised more than 52 percent of the total fatalities (see Lim, 1993).

It should be noted that the proportion of pedestrians involved in fatal accidents contrasts sharply with those of the ESCAP data. The data report that only 1 percent of deaths involved pedestrians in the Republic of Korea, which is an unrealistically low figure, while a paper by Pyong Nam Lim at the 1993 Conference on Asian Road Safety (CARS) reported the above figures.

Furthermore, more than half of all pedestrian casualties occur among those of working age (21-60) while another 30 percent involve children (15 or younger).

Singapore

25 percent fatal accidents,
17 percent injury accidents

In 1993, Singapore reported 241 fatal accidents and 5,559 injury accidents, with pedes trians involved in 61 fatal and 930 injury accidents. Pedestrian casualties have been decreasing in absolute number and relative share of total casualties.

Between 1970 and 1986, they dropped from 3,250 to 1,293 — i.e., from 32 percent to 15 percent of all casualties.

Pedestrian deaths decreased even more significantly with only 69 pedestrians killed in 1986 (28 percent of the total fatalities) compared to 131 in 1970 (46 percent of the total fatalities).

In Singapore, adults over the age of 60 account for half of all pedestrian deaths.

Taipei,China

19 percent fatal accidents,
13 percent injury accidents

In 1993, 2,068 road accidents involving deaths were reported (along with 628 reported injury accidents), equal to a decline of more than 40 percent since 1989. Pedestrian accidents have been reported to be decreasing in recent years with only 393 fatal pedestrian accidents in 1993 compared to 829 in 1987 and only 79 pedestrian injury accidents compared to 914 in 1986.

The unrealistically low pedestrian injury accident figure brings the accuracy of the data into question.

b) Central Asia

PRC

11 percent fatal accidents

The *1995 China National Road Accident Statistics* report shows that in 1994, pedestrians accounted for 11 percent of the PRC's 66,362 road accident deaths, while a *Transportation Research Record* (*TRR*) article reported that cyclists and pedestrians accounted for 60 percent of the country's deaths in 1992.

In Beijing, pedestrians were reported as representing almost 16 percent of road accident deaths and nearly 13 percent of injuries between 1981 and 1985 (see Navin, 1994).

c) Southeast Asia

Malaysia

15 percent fatal accidents,
9 percent injury accidents

The 1994 Malaysia *Statistical Report on Road Accidents* provided details of the country's road accidents and related casualties. Out of 5,159 road accident deaths and 43,344 injuries, pedestrians accounted for 780 (15 percent) and 4,083 (9 percent), respectively.

Malaysia, with the second highest motor vehicle ownership level (because of the number of motorcycles) among the developing countries in the Asian and Pacific region, does not appear to have a serious pedestrian accident problem. Yet since 1987, pedestrian casualties have increased significantly with deaths up by 73 percent, and serious injuries by 61 percent, although slight injuries increased by only 10 percent. Between 1986 and 1988, pedestrians accounted for 15 percent of total casualties compared to the current rate of 10 percent, implying that the accident involvement rate for other road user casualty groups is increasing even faster than for pedestrians.

One third of all pedestrian casualties in Malaysia involve those under the age of 11, while the peak age is between 6 and10, a group in which 23 percent of all pedestrian casualties occurred. Total casualties (all modes) peak later (age 16-20) with only 6 percent of total casualties involving those under 11 years old.

Thailand

9 percent fatal accidents

Almost 85,000 road accidents were reported to the police in Thailand in 1993, of which 9,496 involved a death and 25,330 involved an injury. The 898 pedestrian fatal accidents reported represent more than a doubling in the past three years and an eightfold increase since 1988. However, this number represents only 9 percent of the total fatal accidents.

d) South Asia

Bangladesh

Dhaka: 62 percent fatal accidents,
32 percent injury accidents

Accident data are not collected by casualty class and so the number of pedestrian casual-

ties nationwide is not known. In Dhaka, a review of the police's 1992 *First Information Reports* concluded that pedestrians accounted for 60 percent of all deaths. TRL's Microcomputer Accident Analysis Package (MAAP) was introduced in a pilot project in Dhaka in 1995 and has been operational throughout the city since January 1996. Preliminary findings indicate pedestrians accounted for 152 (61 percent) of the 249 deaths, 83 (31 percent) of the 265 serious injuries, and 42 (16 percent) of the 262 slight injuries. Pedestrians were involved in 143 of the 230 fatal accidents (62 percent) and 98 of the 306 injury accidents (32 percent) reported.

India

Up to 60 percent road deaths

In 1992, 285,900 road accidents were reported with 59,720 involving deaths and 276,747 involving injuries. Although pedestrian data are unavailable for 1992, 1991 figures show that pedestrian involvement in accidents amounts to 2 percent of all deaths and injuries. Pedestrian injury accidents have been reported to be declining from 9,014 in 1984 to 5,091 in 1991, while pedestrian fatal accidents have been reported to be decreasing from a high in 1985 of 1,176 to 982 in 1991. *The Road Safety Digest* estimated pedestrian deaths to represent between 35 percent and 40 percent of total road deaths in metropolitan cities in India and pedestrian deaths have been found to be as high as 60 percent of India's total road deaths (*Road Safety Digest*, 1995). Hence the extremely low percentage of nationally reported pedestrian accidents must be questioned.

Nepal

45 percent fatal accidents,
16 percent injury accidents

Since 1995, Nepal's traffic police have begun to collect national details on each injury road accident and have found that during February and March 1996, pedestrians accounted for 49 (45 percent) of 109 deaths and 83 (16 percent) of 505 injuries. Pedestrian deaths accounted for more than a third of all pedestrian casualties.

MAAP was recently introduced in Kathmandu and on an adjoining highway. The first accident summary reported pedestrians to be involved in 44 percent of all accidents and 52 percent of deaths in Kathmandu in the last half of 1995. On the Naubise-Mugling section of the Prithivi Highway, pedestrians were involved in 48 percent of all accidents.

A six-month study into serious bus accidents (i.e., those involving injury) found a total of 235 serious bus accidents, 107 of which involved pedestrians. Of the 234 deaths caused by bus accidents, pedestrians accounted for 61 and 131 of 1,164 injured (11 percent). Thirty percent of the fatal pedestrian bus accidents occurred at night.

Pakistan

Karachi: 50 percent fatal accidents

No national pedestrian accident data were available for Pakistan, but Karachi, with the only computerized accident reporting system (MAAP) in the country, was able to provide some pedestrian accident statistics. Pedestrians accounted for 50 percent of all casualties and 50 percent of all deaths, although a high percentage (47 percent) of pedestrian casualties were deaths. In 1991, 84 percent of all pedestrian casualties were male and 29 percent were under the age of 16.

More than 70 percent of pedestrian deaths occurred while crossing the road and 87 percent occurred away from junctions. Only 4 percent of pedestrian deaths happened while walking in the road and 28 percent of all pedestrian deaths occurred during the hours of darkness.

Sri Lanka

45 percent fatal accidents,
48 percent injury accidents

A total of 1,346 fatal road accidents and 13,986 injury accidents were reported in 1993 in Sri Lanka. Pedestrian fatal accidents have fluctuated in the past five years and 603 were reported in 1993 compared to 627 in 1988, while pedestrian injury accidents reached a high of 6,743 in 1993, an increase of more than 30 percent in the last five years. Pedestrian fatal accidents make up 45 percent of the total fatal road accidents while pedestrian injuries make up 48 percent of the total injury road accidents.

e) PDMCs

Fiji

43 percent fatal accidents

In 1993, there were 34 pedestrian deaths, 154 serious injuries, and 216 slight injuries.

The most recent accident statistics for Fiji identified the peak age group for pedestrian casualties as between the ages of 6 and 10 (20 percent of all pedestrian casualties, yet only 8 percent of total casualties). Four out of every five pedestrian casualties under the age of 11 were hit while crossing the road, with 15 percent occurring while using a pedestrian crossing.

The younger pedestrian casualties had a much better survival rate as only 6 percent of casualties under the age of 16 died, while 83 percent of the pedestrian casualties over the age of 60 were fatal (*Fiji Road Accident Statistics*, 1994).

Papua New Guinea

33 percent fatal accidents,
15 percent injury accidents

In 1992, pedestrians accounted for 88 deaths, 210 serious injuries, and 142 slight injuries caused by road accidents. Pedestrian shares of total casualties have remained stable over the past five years, despite pedestrian deaths decreasing by 13 percent to 33 percent of the total deaths, and pedestrian serious injuries decreasing by 26 percent to 15 percent of the total injuries.

The reductions are similar to the 1987-1992 overall decrease in total casualties. Papua New Guinea pedestrian slight injuries were reported to be one third less than the pedestrian serious injuries and 17 percent of all pedestrian casualties were deaths.

One third of all pedestrian casualties involved children (15 years or younger) in 1992. Pedestrian casualties peaked in the age group 6 to 10, accounting for 19 percent of all pedestrian casualties, and half of all casualties occurred between the ages of 16 and 30.

A recent TRL publication, *Pedestrian Accidents and Road Safety Education in Selected Developing Countries*, presented pedestrian accident and casualty data from Papua New Guinea in 1992. Findings included 44 percent of pedestrian deaths occurred during road crossings, compared to 36 percent while walking in the road.

Of the latter, two thirds were reported to have occurred when the victims walked with their backs to traffic. The majority of pedestrian deaths (82 percent) occurred away from junctions, with 59 percent killed in rural areas and 29 percent at night. Males accounted for 66 percent of all pedestrian casualties (see Sayer and Downing, 1996).

Samoa

50 percent fatal accidents,
37 percent injury accidents

In 1993, Samoa had five fatal accidents and 45 injury accidents involving pedestrians, accounting for half of the 10 total fatalities and more than one third of the 122 injuries reported.

3.3 Pedestrian Facilities

All countries visited provided a range of pedestrian facilities and while, in most cases, the overall provision was considered to be inadequate, there were often good examples worth considering for use by other countries. The more industrialized countries typically have had a longer history of catering for pedestrians. Some good and bad examples of measures and facilities are described below.

Pedestrian facilities attempt to balance the competing needs of pedestrian safety and convenience, and vehicle movements. There will always be a trade-off between these needs, and evaluation is necessary to assess the effectiveness of the various levels of provision. The following section illustrates the kinds of measures that can and have been implemented to assist pedestrian safety.

However, given the limited transferability of other countries' findings and insufficient accident data, the effectiveness of pedestrian facilities and remedial measures should be closely monitored.

Japan, faced with a serious pedestrian safety problem in the 1970s, attempted to redress the balance and undertook intensive construction of pedestrian facilities.

Between 1971 and 1981, zebra crossings increased more than fourfold to 573,000, while grade separated pedestrian crossings almost doubled to 178,000.

Footpaths (and bicycle lanes) were also greatly expanded from 26,200 kilometers (km) to 92,700 km. Rather than concentrate exclusively on hazardous locations, Japan took a proactive approach to improving pedestrian mobility and provided off-street playgrounds for children, junction channelization, and bypasses (see Koshi, 1984).

This approach has since been recommended for developing countries in the Asian and Pacific region, as the extent of pedestrian accident involvement justifies prompt action (see Koshi, 1996).

a) Roadside facilities

(i) Footways on urban roads

As modal segregation offers the best protection for pedestrians, footways are necessary to provide pedestrians with an alternative to sharing the carriageway with vehicles. Yet despite the heavy reliance on walking in developing cities, footpaths often do not receive priority and are constructed only if adequate space is available after the necessary road width has been provided. As pedestrian counts are rarely conducted, the justification for additional or widened footpaths is rarely documented.

Dhaka, **Bangladesh**, offers a good example of how pedestrian flows are not given adequate attention. Although six out of every ten trips are by foot (and another two by rickshaw), only half of the city's three- and four-lane roads have footways. A recent United Nations Development Programme (UNDP) traffic management study found only two out of the six junctions with the highest traffic flows had footways on all approaches, while 80 percent of the recommended junction designs included footway widening or improvements. This implied that only 20 percent of junctions studied were thought to have adequate footway facilities (see Dhaka Integrated Transport Study [DITS], 1994). In Beijing, **PRC**, inadequate footways in the mid-1980s led to carriageway edges being railed off for pedestrians.

Begun in the late 1970s, the Calcutta, **India**, Traffic Engineering Project aimed to give equal emphasis to footways and carriageways. Surveys of walk speed, density, and flow were conducted during peak and off-peak hours at 20 sites in Calcutta. A minimum design density of 42 pedestrians per minute per meter (ped/min/m) was recommended (equal to a density of 0.6 pedestrians per square meter [ped/m^2]) while the desirable density standard was 23 ped/min/m (density of 0.3 ped/m^2). These values are similar to the density used in Beijing, **PRC**, of 40 ped/min/m. The City Roads Design Principles published by the Beijing City Design Committee also recommended a minimum footway width of 3.5 meters (m) with 2 m for the footway, 0.8 m for the outer verge, and 0.7 m for the inner verge (Martin Voorhees and Associates [MVA], 1986).

Given the demands on prime urban space for economic and social activities in developing countries, footways need also to be maintained for pedestrian usage if they are to minimize conflict with vehicles on the carriageway. While maintaining footways and removing obstructions and encroachment will be difficult, priority locations such as the busiest junctions or known accident black spots should be0 kept clear of obstructions so that footpaths are available for pedestrians.

Footways should not be allowed to be used as parking space. Although authorized parking is rarely provided in developing cities, parking should be restricted to roadway space and no vehicles, including two-wheelers, should be allowed to park on the footway. While footways are often required to accommodate street furniture, a more recent threat has been from plantation boxes whose amenity value is thought to justify the intrusion and reduction of footway space available for pedestrians. Visibility problems, however, can also result, with bushes masking pedestrians and restricting pedestrians' vision.

(ii) Footpaths along rural highways

While footways are almost exclusively considered for urban locations in motorized coun-

Table 3.4: South African Rural Highway Footpath Design Criteria

Footway	Average daily traffic	Pedestrian flow per day	
		Design speed or speed limit (60-80 km/h)	Design speed or speed limit (80-120 km/h)
One side	400-1,400 more than 1,400	300 200	200 120
Both sides	700-1,400 more than 1,400	1,000 600	600 400

Source: CSIR, *Pedestrian Facilities Guidelines*, 1992.

tries, the reliance on walking in developing countries often necessitates siting pedestrian footways on rural highways. Table 3.4 presents **South African** design criteria for paved pedestrian footways outside urban areas.

The South African manual also recommends rural footways of a minimum width of 1 m and 1.5 m in periurban areas. Footways should be separated from the roadway by at least 3 m where possible, and where footways are located on sharp bends, guardrails may need to be installed.

Pedestrian needs were not considered in the original planning stage of the Highlands Highway in **Papua New Guinea**, but as the road is heavily used by pedestrians, the Department of Transport has since contributed to the funding of a 13 km footway pilot project. After 5 km of footways had been constructed, two thirds of pedestrians surveyed chose to use the unsealed 1 m wide footway located alongside the drainage ditch rather than the sealed road. Preliminary analysis of accident data indicated that annual pedestrian accidents had decreased by 50 percent along that section while increasing at the control sites without footways by 40 percent (see Hills et al., 1991).

In **Nepal**, a road improvement project funded by the Overseas Development Administration (ODA) of the UK has proposed using the diversion road (located at the base of the embankment) for pedestrian movements. The diversion road would be made permanent and sealed as a joint 3 m wide footpath and ox cart path. The total cost for converting 14 km of the diversion road was estimated at about US$70,000.

The provision of footpaths adjacent to shade trees along rural highways has also been proposed in Nepal. To encourage pedestrians away from the road shoulders, a sealed 1.5 m footpath has been recommended along the highway near factories. Footpaths must be sealed, otherwise pedestrians will prefer to walk on the carriageway. Since factories operate 24 hours a day, an alternative to the road shoulder will be especially helpful for pedestrian safety at night.

Highways should also continue footpaths over any bridge encountered (minimum 1.2 m footway width on bridge). This is particularly important because many bridges in developing countries are narrower than the approaches and accidents often occur near or on bridges. Plate 3.3 shows a bridge lacking a footway, creating the potential for conflict. If the flow of pedestrians is significant and it is not possible to mark off an area of the bridge for pedestrian use, consideration should be given to providing a separate wooden walkway beyond the bridge parapet by cantilevering out from the existing bridge.

Plate 3.3: Lack of footway provision on a road bridge in New Delhi, India.

(iii) Shoulders

Where pedestrian traffic is significant but insufficient to justify a footpath, hard shoulders should be sealed in order to provide a smooth compacted surface for pedestrians, as a comparable but preferable alternative to the paved roadway. Edge lines should also be marked to provide pedestrians with a visual cue of where the shoulder ends. Colored shoulder surface treatment is unlikely to be affordable, but high quality and durable edge line markings should be marked and maintained to define the safe areas for pedestrians.

(iv) Pedestrian precincts

Pedestrianized areas are rarely found in the Asian and Pacific region despite high pedestrian densities and the predominant share of walk trips. Rare examples include the redesign of road space and service areas for the convenience and safety of pedestrians at two rail stations in Mumbai, **India**, in 1982. In the **PRC**, some pedestrianized streets allow pedal cycle access at certain times of the day. Although not an ideal situation,

shared cycle use of pedestrianized streets is preferable to forcing the NMVs to use dangerous alternative routes where they may be in conflict with motorized vehicles.

Pedestrian precincts improve safety as they tend to be free of accidents. However, pedestrianization holds limited potential for improving overall pedestrian safety in the developing world.

b) Crossing facilities

As the majority of pedestrian accidents occur while crossing a road, the need for safe and efficient pedestrian crossing facilities could arguably be the most important pedestrian safety factor.

Plate 3.4: Pedestrian street in the PRC. Note vehicles excluded for certain times of the day.

Plate 3.5: A pedestrian crossing passing over six lanes of traffic in New Delhi, India.

(i) Pedestrian refuges

Pedestrian refuges are a common pedestrian crossing feature in developed countries, yet they are rarely used in the developing countries of the Asian and Pacific region. In **South Africa**, a properly designed refuge island is assumed to reduce pedestrian risk by 50 percent (see Centre for Scientific and Industrial Research [CSIR], 1992).

Where pedestrian and vehicle flows are insufficient to justify controlled crossings or dualization, pedestrian refuges allow pedestrians to cross the road in two stages. Pedestrians should not have to cross more than two lanes of traffic at a time without a central median provided for refuge. Many of the capital cities in the Asian and Pacific region have wide roads, especially Beijing, **PRC**, and Seoul, **Republic of Korea**, and would benefit greatly from the introduction of pedestrian refuges to ease the crossing problems of pedestrians.

In Bangkok, **Thailand,** pedestrian crossing noncompliance was found to be greater on two-way roads than on one-way roads (no relationship was found between pedestrian demand and noncompliance) but this was believed partially due to the pedestrian refuges located on two-way roads (pedestrian refuges are not provided on one-way roads). Pedestrian compliance was found to be related to the number of traffic lanes to be crossed as well as traffic characteristics (see Jamieson Mackay and Partners [JMP], 1988).

Pedestrian refuge islands should, wherever feasible, be at least 2 m wide and preferably be painted with reflective markings to maximize conspicuity. Where space does not allow a 2 m refuge, a 1.5 m refuge can be used. In Beijing, **PRC**, the standards are more restrictive with a preferred minimum width of 1.8 m, although the absolute minimum width is recommended to be no less than 1.2 m.

Pedestrian refuge facilities should be monitored to ensure they are achieving the desired effect. While the presence of a central refuge may reduce vehicle speeds (by narrowing road width) and simplify the decision making process (fewer lanes to cross and less approaching traffic), it subsequently doubles the number of judgment calls required and pedestrian safety improvement should not automatically be assumed.

Central refuges can be designed to allow a staggered crossing, which would guide pedestrians to face oncoming traffic before they complete the second half of the crossing. However, staggered crossings can cause difficulty for people walking with a bicycle and are not recommended for joint pedestrian/cycle crossings.

(ii) Medians

The benefits for pedestrians from medians are rarely appreciated. Where crossing movements are uncontrolled (as in the vast majority of roads in developing cities) and where kerbed medians are used, the design should be pedestrian-friendly and avoid introducing unnecessary obstacles or risks to pedestrians. For example, in Dhaka, **Bangladesh,** where narrow and round-topped medians have been used on the primary roads, they have added to the pedestrian crossing challenge. Trees have also been planted along some medians, causing visibility problems.

In Beijing, **PRC**, the few central medians provided are usually too narrow at only 1 m to

1.5 m wide and often are built from barriers that provide no storage width. Medians constructed from low-concrete blocks provide little protection from traffic. The city's design principles recommended a minimum central reserve width of 2 m, the absolute minimum allowed at restricted sites is 1.2 m.

The Central Road Research Institute in **India** is conducting research into the types of medians being constructed in New Delhi and their relative effectiveness. Negative impacts can arise with dualization as speeds increase. Dualization has long been credited with improving road safety by separating traffic flows, preventing head-on collisions, and allowing pedestrians to use the median to cross in two stages. However, in some cases, increased speeds may outweigh the safety benefits. For instance, a 300 m section of a highway in **Papua New Guinea** was upgraded to a dual carriageway and while head-on, rear-end, and sideswipe accidents were reduced significantly, pedestrian accidents and off-road accidents doubled. Moreover, while the multivehicle accident types were minor, the sideswipe accidents, although smaller in number, involved mainly serious and fatal accidents (see Hills et al., 1991).

Plate 3.6: A wide pedestrian crossing without central refuge in the Republic of Korea. Note the vehicle is not giving way to pedestrians.

Plate 3.7 (right): Pedestrians having to cross six lanes of high-speed traffic, with no facilities to assist them in New Delhi, India.

(iii) Zebra crossings

Zebra crossings (where pedestrians are supposed to be granted immediate priority over approaching vehicles) are provided in some developing countries, but in the vast majority of cases, can be quickly dismissed as a token measure with few, if any, actual benefits. Studies conducted over the years in Dhaka, **Bangladesh**; Surabaya, **Indonesia**; Karachi, **Pakistan**; Colombo, **Sri Lanka**; and Bangkok, **Thailand** have confirmed that almost no drivers stop for pedestrians using crossings (see Sayer, 1994). While zebra crossings are the most affordable of formalized pedestrian crossings, the disrespect shown to them by pedestrians and drivers renders them of little practical use at any cost.

A study conducted more than a decade ago in the **Republic of Korea** found that almost 40 percent of pedestrian accidents occurred on or near pedestrian crossings (see Ross, 1984). A recent review of pedestrian facilities in the Republic of Korea suggested little improvement had been achieved in pedestrian crossing safety.

While standardized warrants exist for zebra crossings in motorized countries, in most developing countries, zebra crossings are determined on the basis of human judgment. Few countries consider pedestrian desire lines; i.e., the preferred crossing route or the pedestrian and vehicle traffic flows that serve as the basic factors for warranting zebra crossings in developed countries.

Zebra crossings are not considered appropriate for heavily traveled roads and many countries restrict zebra crossings to roads with low vehicle flows. One of the criteria used in **Hong Kong, China** for installing zebra crossings is that the flow should be less than 1,000 vehicles per hour. Unfortunately, unprotected at-grade pedestrian crossings on low volume roads have been found to be dangerous, as vehicle speeds tend to be high when traffic volume is low. In addition, excess road space and obstructed visibility were found to contribute to pedestrian accident risk.

The zebra crossings with bad accident records in Hong Kong, China had all been installed on wide roads (two-lane roads more than 10 m wide or four-lane roads) where on-road parking restricted visibility (see Craddock, 1993).

(iv) Traffic signal controlled pedestrian crossings

Unlike zebra crossings, signalized pedestrian crossings offer the default priority to vehicle traffic with pedestrians allowed to cross only on signals. Unfortunately, like zebra crossings, they are not self-enforcing and rely on driver compliance with crossing regulations. In Bangkok, **Thailand**, surveys found signalized crossings to have a higher compliance rate (39 percent to 74 percent) than did police-controlled (20 percent) crossings.

Plate 3.8: Poor planning of a pedestrian crossing in New Delhi, India, leading to a heavily planted verge.

Signalized pedestrian crossings are recommended where pedestrian volumes are high and pedestrians need to be platooned to avoid continual disruption of vehicle streams. Pelican crossings (pedestrian-operated signal-controlled crossings) have been proposed for several locations in **Nepal** due to this factor. Pedestrian phase length is determined by walk speed and 1.2 meters per second (m/s) is the common standard used, although slightly higher values have been used in Beijing, **PRC** (1.3 m/s) and Bangkok, **Thailand** (1.6 m/s to 1.7 m/s).

Pedestrian accident data analysis of **Hong Kong, China** in 1991 determined that a third of all pedestrian injuries occurred while pedestrians were on or near (within 15 m) a signalized crossing (see Craddock, 1993). Pedestrian misuse of the facility was a problem as many pedestrians chose to cross against the pedestrian signal.

Signalized crossings are costly and require reliable maintenance support, as any operational problems can quickly cause pedestrians to lose confidence in the facility. Given the probability of low driver and pedestrian compliance and the problems of ensuring adequate maintenance, signalized crossings are a risk few developing countries can afford to take.

The effectiveness of zebra and signalized pedestrian crossings should be evaluated. If pedestrians are not using them and drivers not respecting the crossing, then the facility should either be modified (by adding a guardrail) enforced (police controlled), or removed. Pedestrian crossings should be used only where they make a difference and not where they lower the general respect for such measures.

(v) Raised pedestrian crossings

Raised pedestrian crossings were introduced in Karachi, **Pakistan**, in 1987 at three sites and compared with two pelican crossings and three control sites. Pedestrians then accounted for more than half of all Karachi's road accident deaths and almost three quarters of pedestrian casualties occurred during road crossings. Surveys showed that few vehicles stopped for pedestrians on the designated crossing and that while drivers were aware of the pedestrian crossing regulations, they chose to violate them.

In addition to forcing drivers to stop for pedestrians, raised pedestrian crossings had the potential benefits of:

reducing approach speeds, which reduced the likelihood of an accident and the relative injury severity of any accident that did occur. Pedestrian judgment perception would also benefit as safe gap misperception increases sharply with vehicle speed;

increased pedestrian usage, as the crossing would be an extension of the footpath and at the same level, unlike other crossing points on the road; and

increased visibility and conspicuity, as pedestrian height is raised and so they are more easily visible to drivers.

The recommended layout of the crossing included a triangular warning sign proceeded by two sets of road humps of increasing height followed by a raised zebra crossing of further increased height. Unfortunately, in implementing the measures the preceding alerting and warning humps were constructed higher than recommended while the hump at the crossing was lower.

Not surprisingly, given the errors in implementation, evaluation of the effectiveness found mixed results: while accidents were reduced, insufficient accident data from any previous period prevented any firm conclusions. While vehicle approach speeds were reduced by a greater degree than at the zebra and control

sites, this might have been more due to congestion than the humps. Despite the reduced speeds, the stopping behavior of drivers was not improved — less than 1 percent of drivers chose to stop for pedestrians using the crossing. At the raised crossing that performed the worst, resurfacing removed the markings and almost certainly contributed to the lack of impact on driver behavior.

Although driver compliance remained low, speeds were reduced to below the critical level of 30 km/h (average speeds at the raised crossings were between 20 km/h and 25 km/h) at which pedestrians are expected to suffer only slight injuries. With a heavy commercial vehicle flow, reduced speeds are even more important for pedestrians.

There is, however, the disadvantage of drivers having to reduce speed for the crossings (average delay ranged from a few seconds for motorcycles to 40 seconds for buses at one site), whether or not pedestrians are using the crossings. As with all types of uncontrolled crossings (such as zebra crossings), raised pedestrian crossings are not appropriate for roads with heavy or fast vehicle flows, or where pedestrian flow is heavy and could cause a continual source of disruption to vehicular traffic.

Raised pedestrian crossings have been used successfully in **Fiji** on relatively low flow roads and are common in traffic calming schemes in developed countries.

(vi) Grade separated pedestrian crossings

With the increase in traffic levels (both vehicle and pedestrian) and lack of compliance with pedestrian crossings, pedestrian overpasses are being used more often as they can accommodate pedestrians without interference from vehicle flows. The recent Sixth **Malaysia** Plan funded the construction of 29 pedestrian overpasses, and permanent and temporary steel footbridges are being constructed in Dhaka, **Bangladesh,** and Kathmandu, **Nepal**.

Overpasses will not be used if they are perceived to require longer traveling time. So guardrails are often required to prevent more convenient (but more dangerous) at-grade crossing. Utilization of pedestrian overpasses in **Malaysia** ranged from under 3 percent to more than 96 percent, but no information was given on the presence of guardrails.

A 6.5 m high pedestrian overpass was constructed outside a boys' school in Karachi, **Pakistan**, and to promote usage, 1.5 m guardrails were put up on the central reservation and for 150 m along each side of the road. Despite these measures, surveys found more than two thirds of pedestrians crossed at grade level by either climbing over or finding gaps in the guardrails. It was estimated that crossing on the overpass took 12 seconds longer (total 45 seconds) than crossing at grade. The low vehicle flows were thought to have contributed to the attraction (low-risk perception) and the prevalence of at-grade crossing. No before/after accident data was provided (see Sayer and Baguley, 1994).

Pedestrian desire lines (mentioned earlier) need to be considered carefully, as trade-offs often will exist between alternative overpass locations. In Dhaka, **Bangladesh**, a pedestrian overpass was constructed near the airport entrance. While the overpass was specifically located to access the airport railway station and the designated bus stop, pedestrians cross at the nearby roundabout, which has no pedestrian facilities but connects with the highway. Buses choose to stop along the road for such passengers. Other Dhaka overpasses were constructed finishing on the nearside of the road with pedestrians required to cross busy roads to access the main road or local developments (see DITS, 1994).

Underpasses are less common as they are more costly and in the subcontinent frequently suffer flooding. Dhaka has been constructing three underpasses, although no public consultation was conducted and both utility and flooding problems have been encountered.

(vii) Junctions

According to available data, it appears that most pedestrian accidents occur away from junctions. While this might be due to dispersed crossing demand, the lack of pedestrian consideration generally shown at junctions gives pedestrians little incentive to go out of their way to cross at a junction.

Crossings should be marked across all approaches (except at T-junctions where they should be marked across two approaches) and should be the width of the footpath. Pedestrian crossing locations must be carefully considered as they are often sited in awkward places, obstructed by trees or street furniture. As shown in Plate 3.9, poor guardrail placement can also obstruct pedestrian movement.

Beijing, **PRC,** uses a generous standard of 2,700 ped/h/m as the capacity of a pedestrian crossing, and wide pedestrian crossings have

Plate 3.9: Barriers erected to prevent motor vehicles parking on the footway obstruct pedestrian access to the road.

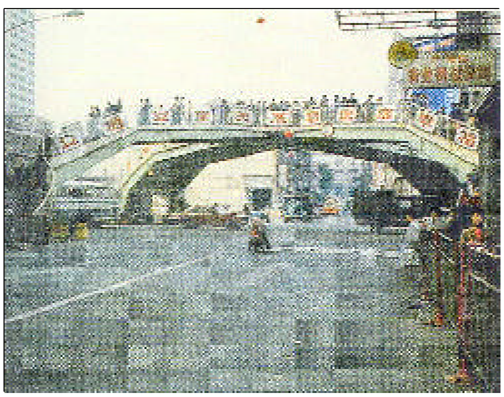


Plate 3.10: Pedestrian overpass in the PRC with guardrailing to channel pedestrians over the bridge.

been constructed at junctions, which have moved the vehicle stop line back. As pedestrians do not always require the full width, driver violations often occur and a revised value of between 4,000 ped/h/m and 5,000 ped/h/m has been recommended with crossing widths of 2.5 m instead of 4 m. Pedestrian refuges have also been recommended for junctions to allow a two-stage crossing, with the refuge sited further back where the road is narrower and vehicle movements more uniform, but where pedestrians will still choose to use the refuge.

At junctions in developed countries, a recent measure has been to extend the main road footpath across the side road end (i.e., a raised crossover), requiring vehicles to change level, however slight, to emphasize pedestrian priority.

Small radii kerbing at junction corners will also help pedestrians by restricting turning speeds, although monitoring is required to ensure large vehicles do not mount the kerb and encroach upon pedestrian safe space. In Beijing, a small corner radius of 3 m is recommended.

(viii) Traffic signal controlled junction pedestrian crossings

Pedestrian phases (all red) are extremely rare and pedestrians often must compete with vehicle movements, especially those turning nearside. The Calcutta Traffic Engineering Project (CTEP), **India**, in the late 1970s recommended banning left turns where the left turn was heavy; i.e., more than 200 vehicles per hour.

A recent TRL Overseas Road Note, *The Use of Traffic Signals in Developing Countries*, summarized the range of pedestrian facilities at signalized junctions, as shown in Table 3.5. An all red phase built in to the cycle was discouraged as it would still be red if no pedestrians were crossing and would be likely to incite driver noncompliance with traffic signals. As pedestrian movements will tend to be more critical on one approach rather than being uniformly distributed, the pedestrian crossing stage should follow the vehicle stage on the critical approach.

Pedestrians tend to cross according to traffic movements and perceived risk rather than the displayed signal. This behavior is heavily dependent upon being able to predict the approaching vehicle's path and **Hong Kong, China** has found the problems detailed below.

1. Asynchronous vehicle movements at a stop line. Pedestrian crossings are often located immediately in front of the vehicle stop line and crossing pedestrians may be hit by a turning vehicle whose approach is obscured by the lanes of waiting traffic. This situation is worsened with unsaturated traffic as this encourages pedestrians to cross and allows high vehicle approach speeds. One junction in Hong Kong, China (approach was only 20 percent saturated and pedestrian flow was quite low — one tenth that of busy shopping areas) had turning movements synchronized with approach movements and accidents stopped. Accidents were related to method of control rather than volumes of pedestrians and vehicles, and a synchronistic method of signal control where vehicle flows are unsaturated should be avoided.

2. Road widens into a pedestrian crossing. After turning movements are conducted, the departure side of the intersection allows through vehicles to spread out and not continue straight as expected by pedestrians.

(ix) Roundabouts

Roundabouts hold mixed potential for pedestrians. While properly designed roundabouts with adequate deflection will result in reduced vehicle approach speeds, the overall crossing area is usually increased.

Pedestrian refuges should be incorporated with the traffic islands providing channelization for the vehicles. If no safe and convenient crossing exists, pedestrians are likely to choose the most direct route and cross on to the center of the roundabout, a behavior not unknown in most countries in the region.

Table 3.5: Summary of Pedestrian Facilities at Signalized Junctions	
Type of facility	**Characteristic**
No pedestrian signal	Traffic signals, even without signals for pedestrians, can help pedestrians to cross by creating gaps in traffic streams. Especially applicable where there are refuges and on one-way streets.
Full pedestrian stage	All traffic is stopped. Demanded from push buttons. More delay to vehicles than combined vehicle/pedestrian stages.
Parallel pedestrian stage	Combined vehicle/pedestrian stage often accompanied by banning vehicle movements. Useful across one-way streets.
Staggered pedestrian facility	Pedestrians cross one half of the carriageway at a time. Large storage area in the center of the carriageway required. Staggered preferably to face oncoming traffic.
Displaced pedestrian facility	For junctions close to capacity. The crossing point is situated away from the junction but within 50 m. Normal staging arrangements as above.

Source: TRL Overseas Road Note 13, 1996.

c) General Design Considerations

(i) Visibility

While visibility obstruction cannot fully explain or excuse such extreme low levels of driver compliance, in Bangkok, **Thailand**, pedestrian delay was found to be reduced where pedestrian crossings had flashing beacons installed. In **developed countries**, zigzag markings on the approach and exit of zebra and signalized crossings are used to indicate where motorists are not allowed to wait, park, or overtake as they could mask a pedestrian using the crossing. In most developing countries, zebra crossings do not have any zigzag markings, additional lighting, or advance warning signs. Road signs are outdated and small in size and almost never reflectorized.

(ii) Lighting

Visibility is a basic requirement of all pedestrian crossings and studies in developed countries have shown that lighting of even a modest standard can reduce nighttime accidents on all-purpose main roads by about 30 percent. While pedestrian accidents in the region appear to have a low nighttime involvement rate, this could be due to reduced reporting priorities or opportunities. Furthermore, nighttime accidents may be overrepresented in terms of trips but not appreciated due to lack of count data. All grade-level pedestrian crossings (mid block and junction) should be checked for adequate lighting.

Supplemental lighting may be required to ensure the whole crossing is properly lit and the pedestrian does not walk in the shadow.

Plate 3.11: A traffic signal controlled junction with a pedestrian phase. Note the lack of formal paved footway leading to the crossing facility.

Plate 3.12: A confusing pedestrian crossing arrangement at a major junction in New Delhi, India.

(iii) Guardrails

Guardrails are used to direct pedestrians towards safe crossings and away from high-risk locations. Research conducted three decades ago in the **UK** found that the presence of guardrails on roads with zebra crossings located every 100 yards (92 m) reduced the percentage of pedestrian crossings between the zebras.

Guardrails should be used at accident black spots and to restrain pedestrians from crossing on primary or higher class roads where vehicle flows should have priority over pedestrians. On local roads, guardrails should be restricted to accident black spots or vulnerable areas such as schools or parks. At present, guardrails seem to be used primarily with pedestrian overpasses. Guardrails will need to be higher than those used in developed countries as they should be of adequate height and design to prevent pedestrians from climbing over, and should be see-through so they do not hamper visibility.

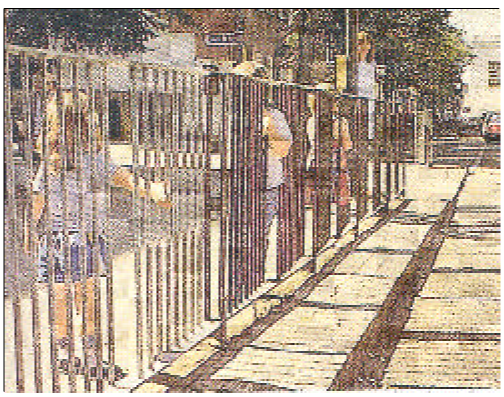


Plate 3.13: Visibility of pedestrians, especially children, has been markedly improved for nearside drivers in the UK, where special "see-through" fencing such as Visirail, has been used

Plate 3.14: An example of a pedestrian crossing in New Delhi, India, with central guardrailing. Note, however, the narrow central median.

3.4 Integrated Programs

The provision of VRU facilities does not guarantee effective usage and compliance by VRUs and drivers. Education and publicity programs are needed to improve understanding and awareness while enforcement can help motivate correct behavior patterns by persuasion (verbal warnings) and punishment. To maximize the impact through synergy, engineering measures should be coordinated with complementary education and enforcement campaigns. Examples are given below.

a) Enforcement

Traffic policing in **Asia** is characterized by limited resources and vehicles, but staffing, of which there is usually no scarcity, can be reallocated to improve pedestrian safety. While most pedestrian accidents occur at mid-link crossings, few traffic police are ever assigned to these locations, although pedestrian accidents are the most common accident type in most cities in the Asian and Pacific region. In recent years, road safety has focused on the need to prioritize the more dangerous moving violations, but this has been limited to junctions and highways and not applied to pedestrian crossings.

Traffic police stationed at junctions rarely give attention to pedestrians and focus on managing vehicle flows. Traffic police could introduce and enforce turning restrictions so crossing pedestrians have a clear phase on the approaches.

Traffic police could also prevent buses from stopping in junctions, and restrict bus alightings and departures to designated locations where pedestrian safety is increased.

Accident data should be used to identify traffic police priorities, which would result in more attention and priority given to pedestrians. Traffic police patrol and point duty allocation could be used to change staffing focus via patrol times or locations. Traffic regulations should be reviewed to assess the deterrence level of the penalty system regarding pedestrian violations.

ODA is sponsoring a road safety project in **Nepal** under which UK police specialists train Nepali traffic police in organizing enforcement campaigns, and pedestrian crossings have been included.

b) Education and publicity

Education and publicity programs are needed for pedestrians and drivers. Traffic education for children should focus on practical survival skills for everyday situations. Children should be taught to use footpaths and when footpaths are not available, they should face traffic while walking. In **Nepal**, where footpaths along rural highways have already been described as scarce, students are being taught to stay to the left of the edge line when walking on the road.

Publicity programs are required to teach the masses who are beyond schooling but have never benefited from any road safety education. Drivers and pedestrians need to learn about the vulnerability of pedestrians, how t hey

account (most likely) for the most common road accident casualties and how drivers and pedestrians can take action to reduce accident risks for pedestrians.

In Nepal, under the same ODA project mentioned above, a pedestrian crossing publicity campaign has been targeted at drivers and pedestrians. The publicity campaign was coordinated with the traffic police's enforcement campaign at pedestrian crossings and the Department of Roads' improvement of, and increase in, pedestrian crossings in Kathmandu.

Plate 3.15: Schoolchildren using a raised pedestrian crossing in Fiji.

Plate 3.16: Schoolchildren crossing the road outside a school under the direction of a school crossing patrol. Note the barriers at either side of the crossing.

4 PEDAL CYCLES AND OTHER NON-MOTORIZED VEHICLES

4.1 Introduction

This chapter reviews safety of NMVs and attempts to identify good practices related to provision of facilities for this group of VRUs. Unfortunately, data and research on this group are far less readily available than for pedestrians, so the depth of analysis must of necessity be limited to what the project team has been able to gather during the project. Although not as complete as the review of pedestrian safety, it is intended that this chapter will, nevertheless, provide insights into how the safety problems of NMVs can be addressed more effectively in the Asian and Pacific region.

4.2 NMV Accident and Vehicle Data

From the limited available data, pedal cycles and other NMVs seem to be involved far less in road accidents than other vulnerable road users (see Tables 2.1 and 2.2). The involvement of two- and three-wheeled cycle-based vehicles in fatal and injury accidents for various countries in the Asian and Pacific region are summarized below in Table 4.1. Accidents involving cycles appear to be high-

Table 4.1: Percentage of Fatal Accidents Involving Cycle-based Vehicles (1) (1993)

Subregion	Country	Fatal accidents (percent)	Injury accidents (percent)
NIEs	**Hong Kong, China** **Republic of Korea** **Singapore** **Taipei,China**	4 0 8 6	4 0 5 5
Central Asia	**People's Republic of China** (1994)	9 (2)	na
Southeast Asia	**Malaysia** (1994) **Thailand**	6 (2) 4	5 (2) na
South Asia	**Sri Lanka**	17	19
PDMCs	**Fiji**	3	6
Developed Countries	**Australia** **New Zealand**	3 3	7 9

na Data not available.
(1) Includes two- or three-wheeled cycle-based vehicles.
(2) Data relates to casualties at national level.
Source: RETA project data.

est in Sri Lanka, comprising 17 percent of reported fatal accidents and 19 percent reported injury accidents.

There are small numbers of cycle-based vehicles involved in accidents in some of the countries (notably **Fiji**, **Republic of Korea**, **Samoa**, and **Singapore**), making meaningful interpretations difficult. However, it was observed that these countries have low numbers of NMVs. Although the **PRC's** National Statistics show NMVs to be involved in only 9 percent of fatal accidents, research from Beijing (see Liu, Shen, and Huang, 1995) shows that cyclists comprise up to 34 percent of those

Table 4.2: Shares of NMV versus Motor Vehicle Traffic on Roads in Asian and Pacific Cities

City	Nonmotorized vehicle (ex-pedestrian) (percent)	Motor vehicle
Dhaka **(Bangladesh)**	51.8	48.2
Phom Penh **(Cambodia)**	52.1	47.9
Shanghai **(People's Republic of China)**	87.2	12.8
Kanpur **(India)**	55.7	44.3
Surabaya **(Indonesia)**	15.6	84.4
Tokyo **(Japan)**	36.1	63.9
Penang **(Malaysia)**	6.5	93.5
Metro Manila **(Philippines)**	33.8	66.2
Chiang Mai **(Thailand)**	2.2	97.8
Hanoi **(Viet Nam)**	64.3	35.7

Source: PADECO Co., Ltd., 1995.

Table 4.3: Growth Rates of NMVs in Selected Cities in Recent Years

City	Type of NMV	Period	Average annual growth rate (percent)
Shanghai **(People's Republic of China)**	Bicycle	1980-1990	14.9
	Other NMV	1980-1990	5.3
Kanpur **(India)**	Bicycle	1983-1992	5.3
	Cycle-rickshaw	1983-1992	2.0
	Pushcart	1983-1992	1.5
	Animal cart	1983-1992	-0.7
Surabaya **(Indonesia)**	Cycle-rickshaw	1985-1992	-0.7
Penang **(Malaysia)**	Cycle-rickshaw	1978-1992	-1.2
Chiang Mai **(Thailand)**	Cycle-rickshaw	1978-1992	8.8

Source: PADECO Co., Ltd., 1995.

killed and are involved in as much as 70 percent of traffic accidents in the city.

While Table 4.1 shows cycle-based vehicle involvement in accidents in various countries, Tables 4.2 and 4.3 permit comparisons of NMV usage and growth in selected cities of the region. (Table 2.3 earlier showed NMV ownership levels throughout the region.) Table 4.3 shows that the trend in Penang, **Malaysia**, is that cycle-rickshaws are declining in numbers, in contrast to the growth in the motorcycle fleet in the country. It is a similar picture in Surabaya, **Indonesia**. These trends reflect a gradual move away from rickshaws towards motorcycle-based vehicles. Following this overview of the Asian and Pacific region as a whole, the detailed accident and traffic data as available for individual countries is presented according to the regional subgroupings.

a) NIEs

Hong Kong, China
Cycles: 4 percent fatal accidents, 4 percent injury accidents

In 1993, 336 accidents involving deaths and 15,133 accidents involving injuries occurred in Hong Kong, China, of which 13 (4 percent) fatal and 556 (4 percent) injury accidents involved cycles. No obvious trends are apparent from these low figures other than to show that cycle accidents are not a big problem.

Republic of Korea
Cycles: about 0 percent fatal and injury accidents

In the Republic of Korea, cycles were involved in nine fatal and 268 injury accidents out of the total 9,471 accidents involving deaths and 251,450 accidents involving injuries in 1993. The total number of accidents involving cycles is insignificant, although fatal accidents involving cycles actually decreased by 74 percent from 1991 to 1993 and injury accidents decreased by 67 percent over the same period.

Singapore
Cycles: 8 percent fatal accidents, 5 percent injury accidents

In 1993, 19 fatal accidents and 265 injury accidents involving cycles occurred in Singapore out of a total of 241 and 5,559 accidents involving deaths and injury, respectively. In percentage terms, cyclists were involved in 8 percent of the total fatal accidents and 5 percent of the total injury accidents. Since 1989, the number of fatal accidents involving cyclists has risen, along with a general increase in their relative share of the fatal accidents.

Taipei,China
Cycles: 6 percent fatal accidents, 5 percent injury accidents

In 1993, 128 fatal accidents involving cyclists were reported out of the total 2,068 fatal accidents, representing 6 percent of the total. The number of fatal accidents has decreased at a fairly constant rate since 1990. Only 31 injury accidents (5 percent) involving cycles were recorded in 1993 out of the 628 total injury accidents recorded. The low injury accident figures call into question the accuracy of the data.

b) Central Asia

PRC
NMVs: 9 percent deaths (Beijing cyclists: 34 percent deaths)

The 1995 *Chinese National Road Accident Statistics* shows that in 1994, 5,675 road deaths involved NMVs, making up only 9 percent of the total road fatalities. However, a *TRR* article by Liu, Shen, and Huang in 1995 relating to Beijing reports that cyclists were involved in 34 percent of accident deaths (1992); furthermore, between 1981 and 1990, about 70 percent of the total traffic accidents involved cycles.

Analysis of fatal accidents in Beijing revealed that between 1981 and 1992, the average rate of cycle involvement in fatal accidents was more than 30 percent, with a maximum involvement rate in 1981 of 43 percent and a minimum level of 25 percent in 1989. Despite a decreasing trend in cycle involvement in fatal accidents up to 1989, cyclist involvement in fatal accidents rose to 34 percent in 1992.

Analysis of age-related data for fatal accidents involving cyclists in Beijing revealed that riders aged over 60 made up only 11 percent of the population and contributed to only 5 percent of the trips made. But this group was involved in more than a quarter of the fatal accidents

Table 4.4: Causes of Accidents Involving Bicycle Deaths in Beijing, PRC, (1981-1990)	
Cause of Accident	**Involvement** (percent)
Unyielding to other traffic	27.0
Sudden turning	26.3
Riding on motorway	16.1
Crossing more than four lanes	8.5
Riding the wrong way	7.7
Reckless riding	5.3
Riding with a passenger	1.9
Poor riding skills	1.2
Riding under the influence	0.9
Others	2.3

Source: *TRR No. 1487,* article by Liu, Shen, and Huang, 1995.

involving bicycles — clearly a target group needing special attention.

More than 80 percent of fatal accidents involving cycles occurred on arterial and subarterial roads in Beijing. This high severity rate was due to the higher operating motor vehicle speeds and a large number of junctions along their lengths.

Indeed, 54 percent of these fatal accidents occurred at intersections, despite many of the intersections being signalized.

Table 4.4 shows the major causes of fatal accidents involving cycles in Beijing between 1981 and 1990. The majority of fatal accidents involved cyclists not yielding to motorized vehicles or carrying out turns, especially across oncoming vehicles. A major problem that has been identified is the mixing of motor vehicle and cycle traffic, especially at junctions where differences in speeds clearly create problems.

The article also notes that farmers had the highest involvement rate in fatal bicycle accidents, due to their poor knowledge of traffic laws, the poor and unsafe condition of their bicycles, higher motor vehicle speeds in rural areas, and the difficulty in receiving prompt medical treatment in rural areas. As a result, rural areas have a higher percentage of fatal accidents involving cycles than urban areas, despite only a third of cycles being owned in rural areas.

One of the main causes of cycles being involved in a high number of accidents in Beijing is the quantity of cycles. Liu, Shen, and Huang

Table 4.5: Registered Vehicles by Type and Year in the PRC

Year	**Motor vehicle** (10,000)	**Bicycle** (10,000)	**Total** (10,000)	**Bicycles as percent of total**
1985	655.65	22,364	23,019.65	97.2
1986	819.07	25,803	26,622.07	96.9
1987	1,061.03	29,313	30,374.03	96.5
1988	1,190.20	33,312	34,502.20	96.6
1989	1,318.53	36,515	37,833.53	96.5
1990	1,476.26	39,099	40,575.26	96.4
1991	1,657.66	41,979	43,636.66	96.2
1992	1,945.03	45,076	47,021.03	95.9

Source: *National Road Accident Statistics*, 1995.

Table 4.6: Percentage of Nonmotorized Vehicles on NMHC Highways			
Year	**Bicycle traffic**	**Fatal accident** (person-drawn and animal-drawn vehicle traffic)	**Total NMV traffic**
1988	8.9	6.8	15.7
1989	8.4	6.5	14.9
1990	8.2	6.1	14.3
1991	7.7	6.0	13.8
1992	6.8	6.4	13.2

Source: Liu, Shen, and Huang, 1995.

claim that as the number of daily cycle trips increases, so do the chances of motor vehicle and cycle collisions.

In 1992, Beijing had nearly 8 million registered bicycles and 700,000 registered motor vehicles.

Table 4.5 shows the number of registered vehicles by type and year throughout the whole of the PRC. It shows that motorized vehicles and bicycle numbers have increased between 1985 and 1992, the rate of growth being about the same for both types of vehicle.

Although nonmotorized vehicles have increased in numbers, their proportion on the National Major Highways of the PRC (NMHC) decreased between 1988 and 1992 (see Liu, Shen, and Huang, 1995). Table 4.6 shows the share of NMV traffic on NMHCs. It is predicted that this proportional decrease will continue into the year 2000.

It should be noted, however, that the PRC's provinces each have different proportions of NMV traffic on the NMHCs.

c) Southeast Asia

Indonesia

Cyclists: 9 percent fatal accidents, 7 percent injury accidents

Thompson and Rudjito in *Traffic Accident Investigation in Indonesia* (1991) report that cyclists comprise 7 percent of injuries to road users and 9 percent of all deaths.

National data on the number and size of the national NMV fleet in Indonesia was unavailable. However, limited data with regard to Surabaya from a PADECO Co., Ltd. (1995) report revealed that NMVs made up only 16 percent of traffic on roads despite 45 percent of the vehicle fleet belonging to the NMV category. The majority of the NMV fleet comprises bicycles, which make up 40 percent of vehicles owned, and rickshaws, at less than 5 percent. No clear national policy exists with respect to NMV provision except to recognize the transport requirements of individual cities.

Table 4.7: Cyclist (NMV) Fatal Accidents by Year in Thailand			
Year	**Fatal accidents involving cycles**	**Total fatal accidents**	**Percent of fatal accidents involving cycles**
1988	489	2,015	24
1989	177	6,963	3
1990	129	5,765	2
1991	104	6,319	2
1992	285	8,184	3
1993	338	9,496	4

Source: RETA project data.

Table 4.8: Vehicles Registered by Type and Year in Thailand			
Year	**Registered NMVs**	**Total registered vehicles**	**NMVs as percentage of the total vehicles**
1990	50,270	7,592,100	0.7
1991	53,930	8,481,000	2.0
1992	37,300	9,595,200	3.0
1993	39,300	11,102,000	4.0

Source: RETA Project data.

Hence, Indonesian cities were observed to exhibit marked differences in the numbers of NMVs and the facilities provided to accommodate them. In Jakarta, for example, cycle-rickshaws have been banned and replaced by motorized motorcycle taxis, resulting in a highly motorized and polluted traffic environment that is unattractive to other two-wheeled and nonmotorized vehicles. However, some NMVs, such as handcarts and cycle-rickshaws, do still appear to operate within Jakarta.

Malaysia

Bicycles: 6 percent fatal accidents, 5 percent injury accidents

In 1994, 326 (6 percent) road accident deaths and 2,177 (5 percent) injuries involving bicy-

Table 4.9: Vehicles Responsible for, or Involved in, Traffic Accidents in Hanoi, Viet Nam (1991)		
Vehicle	**Number**	**Percent**
Bicycle and cyclo	48	11.0
Motorcycle	265	60.6
Xelam	21	4.8
Automobile	13	3.0
Truck and bus	90	20.6
TOTAL	**437**	**100.0**

Source: *TRR No. 1441* (1994).

Table 4.10: Vehicles by Type in Hanoi, Viet Nam (June 1991)		
Vehicle Type	**Number**	**Percent**
Bicycle	1,000,000	84.6
Cyclo	5,100	0.4
Oxcart	0	-
Motorcycle	128,000	10.8
Xelam	1,667	0.1
Auto Rickshaw	0	-
Automobile	35,000	3.9
Truck	11,800	1.0
Bus	160	0.0
TOTAL	**1,180,860**	**100.0**

Source: *TRR No. 1441* (1994).

Table 4.11: Pedestrian and Vehicle Volumes in Hanoi (Based on Peak-hour Surveys at Two Locations in June 1992)

Mode	Number	Percent
Pedestrian	582	7.1
Handcart	0	-
Bicycle	4,578	55.8
Cyclo	321	3.9
Motorcycle	2,377	29.0
Xelam	49	0.6
Auto rickshaw	0	-
Automobile and truck	230	2.8
Bus	66	0.8
TOTAL	**8,203**	**100**

- = magnitude zero
Source: *TRR No. 1441* (1994).

cles were reported out of a total 5,159 and 43,344 road deaths and injuries, respectively, in Malaysia. No obvious trend exists for either casualty figures involving bicycles.

Thailand

Cyclists and NMV three-wheelers: 4 percent of fatal accidents

Only a small amount of data has been collected for Thailand, indicating that 4 percent of accidents involve cyclists or nonmotorized three-wheelers. Despite this, a big increase in the number of fatal accidents involving bicycles occurred in 1993, compared to 1991 (Table 4.7). The 1988 figure is also abnormally high, which raises questions about data accuracy and consistency.

NMVs comprise only a tiny proportion of registered vehicles in Thailand, as indicated in Table 4.8.

Viet Nam

NMVs: 11 percent of all accidents

NMVs are commonly perceived by officials in Viet Nam as being responsible for “50 to 90 percent of all traffic accidents” (PADECO Co., Ltd.). Statistics gathered by the Hanoi Traffic Police and published in *TRR No. 1441*, however, indicate that they were involved in only 11 percent of all reported accidents. Motorcycles were, in fact, responsible for more than 60 percent of the accidents (see Table 4.9).

In Viet Nam, particularly in Hanoi, residents have traditionally depended upon NMVs, especially bicycles and cycle-rickshaws (cyclos). However, rapid motorization is occurring as the country develops and the main growth is in the use of motorcycles. Despite this, traffic counts show that NMVs still account for up to 70 percent of vehicle volumes. Vehicle types and usage in Hanoi are shown in Tables 4.10 and 4.11.

In Hanoi, “plans have been made to abolish all NMVs from operating within the city by the year 2004” (see Bell and Kuranami, *TRR No. 1441*, 1994). However, some provision for NMVs does exist, for example, physically segregated lanes for motorized and slow-moving vehicles. Furthermore, trucks and buses have been banned from using certain roads (see Bell and Kuranami, *TRR No. 1441*, 1994). Consequently, although official government policy appears to be aimed at “abolishing” NMVs, the reality is that they still form a major part of the traffic stream in much of Viet Nam.

d) South Asia

Bangladesh

Dhaka: NMVs, 13.5 percent accidents

Over nine months in 1995 to 1996, a pilot accident reporting project in Dhaka revealed 260 registered accidents; of these, NMVs accounted for 35 accidents (13.5 percent). More than 50 percent of the NMV accidents were fatal, 80 percent of these involved a rickshaw, 43

Plate 4.1: Confiscated rickshaws in Dhaka, Bangladesh.

percent of the rickshaw accidents occurred at T-junctions, and more than half involved a rear-end collision. The data were produced by the MAAP recently installed in Dhaka.

Accident statistics, with respect to cycle-rickshaws, are scarce and unreliable (underreporting is a big problem), but R. Gallagher, in *The Cycle-rickshaws of Bangladesh* (1992), estimates that in 1986 and 1987, cycle-rickshaws accounted for about 10 percent of road deaths in Dhaka (based on newspaper reports). Bus, trucks, and minibuses accounted for 97 percent of rickshaw-related deaths and 100 percent of bicycle deaths.

Gallagher further estimates that there are about 700,000 cycle-rickshaws in the country, with between 150,000 and 200,000 in Dhaka alone — more than half of all Dhaka's vehicles. Bicycle numbers in Dhaka are between 33,000 and 50,000. (Registered cycle-rickshaws numbered 100,000.) However, the observed usage was low. But provincial towns were stated to have a much higher percentage of bicycles in use. The number of cycle-rickshaws is rising (see Table 4.12) and it is estimated that by the year 2000, they will total more than 1.25 million throughout the country.

The 1993 *Statistics Yearbook* gives the following table of total registered cycle-rickshaws in 19 selected municipal corporations, including Dhaka.

Manual traffic counts made on several major national roads (1995) show that on average, NMVs made up 49 percent of the total traffic. NMVs were split between cyclists (29 percent), cycle-rickshaws (66 percent), and carts (5 percent).

It should be noted that there is a general policy in Bangladesh of rickshaw reduction. "In April 1987, the government of Dacca, Bangladesh, announced plans to completely ban pedicabs from the city on safety grounds, although they employed more than 100,000 people" (*TRR No. 1294*, 1991). This policy is still ongoing, as Plate 4.1 shows, but it is a highly political problem. NMV measures observed in Dhaka include both the banning of NMVs on certain sections of road, and the provision of segregated facilities, mostly by carriageway markings.

Numerous heavily-laden pushcarts were also observed throughout the city, but especially in the old part of Dhaka where carriageway widths were extremely narrow in sections, due in part to traders encroaching on to the highway. Congestion was also particularly severe and exacerbated by the horse carts.

Sri Lanka

Pedal cycles: 17 percent fatal accidents, 7 percent all accidents

A report by the Sri Lanka Traffic Police and the Ministry of Transport revealed that between 1986 and 1990, 15 percent of deaths were pedal cyclists and that cycles were involved in 6 percent of all accidents. Cyclists were involved in

Table 4.12: Registered Vehicles in 19 Selected Municipal Corporations (Bangladesh)

Year	Cycle-rickshaws	Motor vehicles	Cycle-rickshaws as percent of total
1988	191,306	270,860	41
1989	270,430	315,530	46
1990	271,858	341,648	44
1991	295,334	364,626	45

Source: PADECO Co., Ltd., 1995.

Table 4.13: Pedal Cyclists as Percentage of all Reported Accidents in Sri Lanka			
Year	**Cycle accidents**	**Total accidents**	**Cycle accidents as percentage of total accidents**
1988	2,191	33,028	7
1989	1,960	31,696	6
1990	2,366	34,463	7
1991	1,842	34,144	5
1992	2,574	37,777	7
1993	2,900	41,495	7

Source: Sri Lanka Traffic Police, 1996.

Table 4.14: Fatal Accidents Involving Pedal Cycles in Sri Lanka			
Year	**Cycle fatalities**	**Total fatalities**	**Cycle fatalities as percentage of total fatalities**
1988	226	1,365	17
1989	224	1,454	15
1990	265	1,714	16
1991	241	1,255	19
1992	231	1,302	18
1993	222	1,346	17

Source: Sri Lankan Traffic Police and the Ministry of Transport.

19 percent of reported injury accidents and 17 percent of reported fatal accidents. This highlights the high risk of death for cyclists involved in accidents.

Tables 4.13 and 4.14 show pedal cycle involvement in accidents and fatalities.

From the tables above it can be seen that the number of cyclists involved in accidents reached a peak in 1990 and then fell to a low in 1991.

Fatal accidents involving bicycles have decreased since 1990 while their percentage of involvement in fatal accidents has also decreased since 1991.

e) PDMCs

Minimal bicycle accidents

Of the 11 island nations representing the PDMCs, data were available only for Fiji. In 1993, only two fatal accidents involving bicycles were recorded. This followed a low number of fatal accidents involving bicycles over the previous five years.

4.3 NMV Facilities

As illustrated in the previous section, large numbers of NMVs are in daily use in many Asian countries. Despite their obvious importance as a transport mode, few cities in the region specifically provide measures to assist NMVs and many roads and networks within some Asian cities appear to have been designed without any consideration for their needs. Indeed, not one city was observed to provide a network of linked measures for NMV users to assist popular journey patterns. However, some interesting and useful solutions to help deal with the high NMV levels do exist and can be observed to be operating successfully throughout the region.

The following section is intended to illustrate and highlight successful NMV facilities from around the region with respect to their general design requirements. However, this report is not intended to be a design manual and seeks only to indicate the general form that these measures can take. The facilities discussed are suitable for pedal cyclists and other

Plate 4.3: Continuous physical segregation by kerbing along an arterial road in Yogyakarta, Indonesia.

Plate 4.2: Physical segregation by a tree-lined verge in Ho Chi Minh City, Viet Nam.

NMVs, but it should be noted that the design of any facility should take into account the expected NMV traffic composition.

While engineering measures assist with safer travel for NMV users, complementary education and enforcement programs increase their effectiveness. This section focuses largely on engineering measures, but some guidance is also provided on related education and enforcement issues.

a) Road links

Various facilities can be provided along road links (sections of a road between intersections) to assist NMVs. These facilities can be categorized into segregated measures, either by physical or visual means, or those measures that help NMVs within a mixed traffic environment.

Segregational measures usually separate motorized and nonmotorized traffic, but at times they divide four-wheeled motorized vehicles from the rest of the traffic. The type of segregation most suitable is dependent on the factors associated with the road hierarchy and land use, such as motor vehicle traffic speeds and volumes, traffic composition, and vehicle accesses. High cycle flows may warrant provision of a segregated facility and will help govern the actual physical dimensions of the facility provided. Total segregation (where NMVs run on a completely separate network of paths to motor vehicles) can also be provided, but no examples of this type have been identified in the region.

Where NMV traffic has been banned from using certain roads, it is important that an alternative network exist for NMV users and that these alternative routes are attractive in terms of safety, comfort, and journey time.

Plate 4.4: Railings used to segregate cyclists and motorized vehicles in the PRC.

(i) Physical segregation

Physical segregation of nonmotorized and motorized vehicles using a barrier or raised track is intended to maximize cyclist safety along road links that have high vehicle speeds, high vehicle flows, or a corresponding mixture of both. The actual barrier or height difference between the running surfaces prevents the interaction of the two types of vehicle. The infrastructure involved in physical segregation requires high initial implementation costs in comparison to visual segregation.

Segregation through raised kerbs helps delineate dedicated cycle lanes alongside major roads. Safety can be increased with the provision of adjacent verges in order to further separate the two modes of vehicle (see Plates 4.2 and 4.3). A raised track or verge edge height should be sufficient to discourage motor vehicle encroachment onto the segregated track. Furthermore, it is also often necessary to prevent illegal use of these paths by motor vehicles by placing bollards at either end of the segregated section. Limited examples of raised and kerb separated lanes were observed in Dhaka,

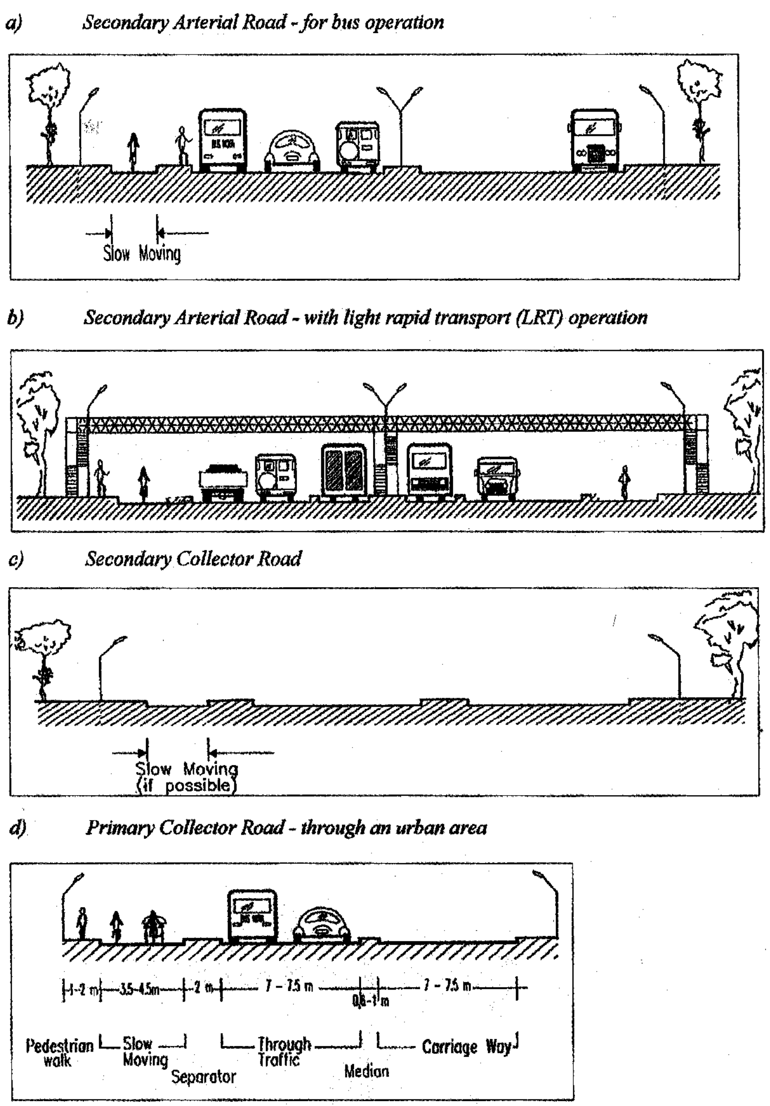
Plate 4.5: Slow-moving vehicle lane for two-way traffic in Yogyakarta, Indonesia.

Plate 4.6 (far right): Physical segregation for NMVs over a road bridge in Dhaka, Bangladesh.

Bangladesh, such as the raised pavements at the High Court and the segregated lane on Mirpur Street; on Malioboro Street in Yogyakarta, **Indonesia;** and in Ho Chi Minh City, **Viet Nam**.

Alternative segregational methods can include periodic barriers, spaced at intervals along the route that may be in the form of upstanding block work, bollards, posts, or even old oil drums, as well as actual continuous barriers such as low railings and walls (see Plate 4.4). In the **PRC** and **Viet Nam**, effective continuous lane barriers have been erected using concrete blocks joined by metal poles that can be dismantled and are moveable when required and yet offer an effective near permanent barrier at many locations in cities in the PRC (see Plate 5.6).

Figure 4.1: Proposed cross-sections in Yogyakarta, Indonesia.



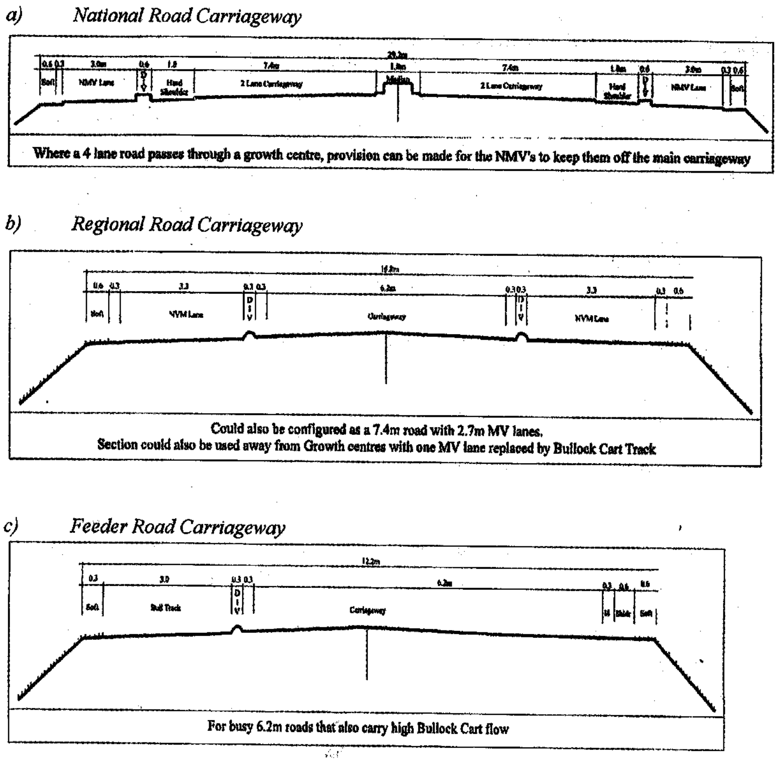
Source: Yogyakarta Urban Development Project, 1995.

Physically segregated paths can be used for two-way cycle flows, but their design must ensure that a satisfactory width has been provided in order to accommodate two- and three-wheeled NMVs, along with any overtaking maneuvers (see Plate 4.5). Particular care also needs to be taken in the design of merging and diverging areas where nonmotorized and motorized vehicles mix.

Segregated facilities for NMVs at pinch points, such as road bridges throughout the region, are rare. However, a few good examples do exist as in Dhaka, **Bangladesh** (see Plate 4.6).

Yogyakarta, **Indonesia,** provides good examples of slow moving vehicle (SMV) carriageway separators, which are intended for flows in two-way and one-way directions according to the road hierarchy. These lanes allow safe and direct travel for NMVs in the town center and on the arterial routes into and out of the city. On lanes with access for service vehicles, protected loading bays are provided in order to prevent disruption of the SMV flows. Lane widths tended to be about 5 m wide in Yogyakarta, allowing three cycle-rickshaws to pass side by side. Signs limited the lanes' use to NMVs and motorcycles, with cars and trucks explicitly banned. The 1995 Yogyakarta Transportation Master Plan also recommends the provision of further SMV lanes (see Figure 4.1).

The proposed 1994 geometric design standards for **Bangladesh** (Road Materials and



Source: Road Materials and Standards Study, Bangladesh, 1994.

Figure 4.2: Proposed cross-sections in Bangladesh.

Standards Study) include cross-section recommendations for the inclusion of NMV lanes on national, regional, and feeder roads. This manual not only provides design dimensions but also capacities for the road categories under consideration. The provision of cart or bull tracks is also catered for on feeder roads (see Figure 4.2c).

(ii) Visual segregation

Visual segregation of nonmotorized and motorized vehicle traffic is provided by white line markings on the carriageway. These nearside carriageway markings can take the form of either broken white lines, termed advisory cycle lanes (see Plate 4.7) in the developed countries, or continuous solid white lines, termed mandatory cycle lanes (see Plate 4.8). Cyclists are recommended to use either of these lanes where they exist; motor vehicles are not permitted to enter the mandatory lane and may enter the advisory lane only when necessary, and only if cyclists are not impeded. Such facilities are dependent on driver compliance and effective enforcement of the traffic regulations.

The type of lane to be implemented is dependent on road hierarchy and land use factors such as carriageway width and parking requirements in the area. For instance, parallel parking alongside the pavement will discourage cycle use of the lane and render it ineffective. Flows along these lanes should be in the general traffic direction only. So lane widths should not be so wide as to encourage two-way cycle flows or to encourage illegal use by motor vehicles during times of congested traffic.

Markings, and hence the integrity of the actual lane can be enhanced by providing wide markings, double-line markings or even hatched areas to denote the separation. Alternatively, yellow paint has also been used to help denote the lane, as in Metro Manila, **Philippines** (PADECO Co., Ltd.). There are limited examples of white lines throughout the region, such as in **Bangladesh** and **Indonesia**. Lanes observed in Dhaka, **Bangladesh**, tended to be 1.5 m to 2 m wide, making them suitable for bicycles, but wide enough for only a single rickshaw, which forces overtaking NMVs to stray outside the lane.

Contra-flow cycle lanes have been implemented in cities in the **PRC**, such as Shanghai, and generally appear to work well with only visual segregation to separate the traffic flows (see Plate 4.9). However, the use of such measures and implementation experience in Asian developing countries outside of the PRC is not known. A system of one-way motorized traffic and one-way NMV traffic is also in use in Shanghai, in addition to the traditional contra-flow system, (see Plate 4.10).

Plate 4.7: Visual segregation for SMVs using broken white lines in Yogyakarta, Indonesia.

Plate 4.8 (far right): Visual segregation for SMVs using a solid white line in Dhaka, Bangladesh.

Plate 4.9: Contra-flow cycle lanes in Shanghai, PRC.

Plate 4.10 (far right): One-way motor vehicle flow and one-way cycle flow system in Shanghai, PRC.

Contra-flow cycle lanes are usually denoted by a continuous white line, although standards in developed countries recommend that physical segregation be provided at the start and end of such sections. Contra-flow cycle lanes can help provide an area-wide network for NMV users by creating direct and cohesive routes. Safe design requires crucial consideration of the lane widths so as to reduce the attraction of traveling out of the lanes into the main carriageway. PADECO Co., Ltd. proposes that with-flow lanes should also be provided in the opposing direction to the contra-flow lane to increase safety; however, this would be at the further expense of the effective motor vehicle carriageway width.

(iii) Mixed traffic

The planned use of mixed traffic of nonmotorized and motorized vehicles can be relatively safe under certain conditions, such as low motor vehicle speeds and flows, along with an appropriate traffic stream composition. Safety aspects relating to VRUs in terms of speed and traffic reduction measures are discussed elsewhere within this report, along with ways of reducing the interaction between incompatible vehicles.

An increasing problem is the growing number of accidents occurring on rural roads having their surface condition improved by road rehabilitation projects. This encourages higher vehicle speeds, which accentuate even further the differences between motor vehicles and NMVs. Additional safety features need to be incorporated when such rehabilitation projects are undertaken to avoid road safety problems. This is particularly so where large numbers of pedestrians, NMVs, or SMVs can be expected. In **Bangladesh**, for example, the mixed environment for cyclists was enhanced by the occasional provision of speed humps to slow down motorized traffic. This is of particular value when rural roads pass through townships or communities.

The provision of facilities for joint use by pedestrians and NMVs without segregation is not recommended where high pedestrian flows exist and should not be the preferred solution where alternatives exist. This approach was, however, observed on busy radial routes in Shanghai, **PRC**.

Where mixed traffic does exist, the widening of nearside road lanes by altering the position of line markings is being carried out in **Australia**, **Europe**, and the **US**. This practice allows a greater clearance distance between cyclists and overtaking motor vehicles. Care must be taken, however, to ensure this inside lane width is of a size to encourage use by two rows of motor vehicles during periods of traffic congestion.

b) Junctions and crossings

The potential for conflicts between nonmotorized and motor vehicles is greatest at intersections where segregation of traffic is not always possible or suitable. As a result, conflicts at junctions account for a large proportion of all cycle accidents, as shown in research carried out in the **PRC** (see Table 4.4). Plates 4.11 and 4.13 show examples of pedal cycle and motor vehicle conflicts at intersections. However, as part of the network design process, NMVs must be given full and proper consideration at junctions, taking into account their specific vehicle characteristics. Plate 4.12 shows an example of how poor planning in the PRC has caused a potential conflict point due to the right-turning traffic having to cut across the cycle lane with no priority markings or signs provided.

Measures to assist cyclists and other NMVs at priority junctions, signal controlled junctions, and roundabouts are considered below,

along with grade-separated facilities such as footbridges and underpasses.

All intersections should be appropriately marked and signposted in order to provide clear instructions and directions to motor vehicle drivers and NMV users alike. The design of any junction with specific NMV provision should include all the normal geometric factors, including sightlines and visibility requirements that would be considered for any other vehicle.

(i) Priority junctions

NMV users should expect the same privileges as drivers of motorized vehicles and whenever possible, should not be prevented from carrying out a full range of legal turning maneuvers at junctions. In order to carry these maneuvers, weaving by cyclists and motor vehicle drivers (in order to be in an appropriate turning lane) is common practice so junctions need careful design. For example, turning NMVs are often extremely exposed when waiting in the center of the carriageway for a gap in the traffic. In order to reduce conflicts, it is suggested that priority junctions be designed in order to minimize the interaction time by reducing the distances to be crossed, for example by reducing turning radii. Short turning movements can be helped by leading cycle lanes away from the junction and on to the adjacent junction arm. No specific operating examples of measures to assist NMVs at priority junctions in the region have been identified to date during the study.

Turning restrictions via physical measures on motor vehicles can have beneficial effects on safety as the interaction between vehicles is reduced. Reduced vehicle speeds and reductions in motor vehicle priority also have beneficial safety consequences for NMVs (see section on Traffic Calming in Chapter 6). Traffic police were commonly observed controlling flows and access at junctions in **Bangladesh**, **PRC**, and other countries. When the police are properly trained, this can be an effective method of traffic control with particular benefits to NMVs.

(ii) Signal junctions

In Beijing, **PRC**, some bicycle traffic signals exist on roads with heavy cycle flows (see Plate 4.14). These signals are cycle-traffic actuated due to the use of bicycle sensitive inductive loops in the road surface (PADECO Co., Ltd., 1993). It should be noted, however, that complex signal-controlled junctions are a costly solution. Given the widespread NMV usage throughout Asia, other less expensive traffic management alternatives should first be

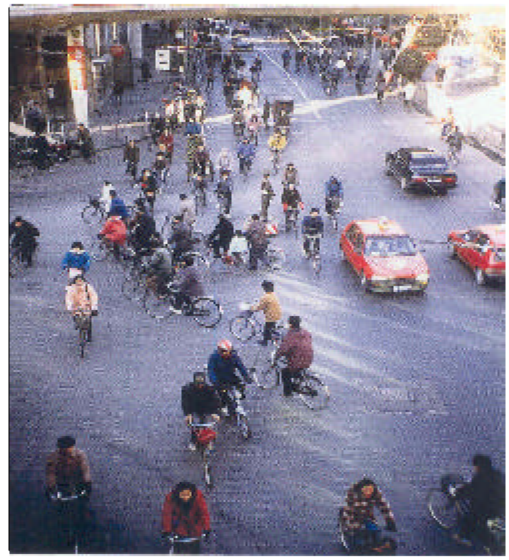


Plate 4.13: Conflicts between cyclists, motorcyclists, and motor vehicles at a junction in Shanghai, PRC

Plate 4.11: A potential conflict at a junction between a cyclist and truck in Hanoi, Viet Nam.

Plate 4.12: Example of poor planning at a junction in Shanghai, PRC. Note that traffic turning right must cut across the adjacent cycle lane.

Plate 4.14: Separate traffic signals for cyclists at a junction in Beijing, PRC.

Plate 4.15 (far right): An advance stop line for cyclists at a signal-controlled junction in Market Harborough, UK.

considered at signal-controlled junctions where traffic levels are high. Examples are given below.

The banning of all opposing traffic movements, regardless of vehicle type, helps reduce the number of potential conflicts. This has been carried out successfully in Ho Chi Minh City, **Viet Nam**, where opposing turning maneuvers have been banned over a series of junctions before a roundabout, for example on Le Lo'i Road and Ham High Road. However, cyclists are particularly vulnerable at roundabouts and it is suggested that variations on the above method be considered. These variations maintain the banned opposing vehicle turning movement but allow NMVs to cross the major road from the minor road using a straight crossing maneuver. This process involves taking the NMV off the major road either before (G turn) or after (Q turn) the junction and then leading the NMVs to the minor road arm of the junction via a series of turns with the general traffic flow. Figures 4.3 and 4.4 illustrate the situation where traffic drives on the right. Note that the left turn is prohibited at point A and traffic is rerouted in order to allow that maneuver.

Conflict reductions have also been achieved in the **UK** and other developed countries by altering the layouts of some junctions in order to allow cyclists access to a waiting area, or reservoir, at the front of the traffic queue but behind a separate cycle stop line (see Plate 4.15). This advance stop line provides the chance for cyclists to carry out their maneuver at the head of the traffic with increased safety and negligible effect on motorized traffic. Naturally, enforcement and driver awareness of these areas to prevent motor vehicle access is necessary and the installation of colored surface materials or clear markings can be useful. Similarly, enforcement to ensure cyclists comply with traffic signals is needed.

Traffic signals at large junctions catering for NMVs should specifically consider the clearance times taken for the vehicles to travel between the arms of the junction. Appropriate signal phasing and timings will help to minimize conflicts.

(iii) Roundabouts

Cyclists are particularly vulnerable at roundabouts and accidents can easily occur due

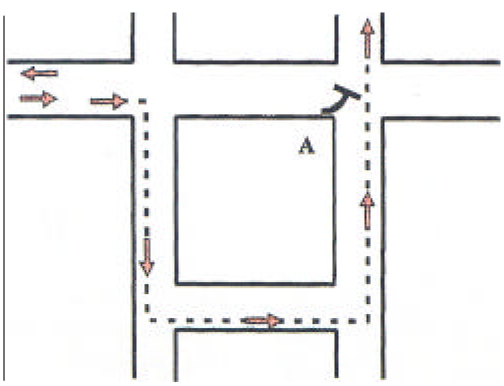


Figure 4.3: A right turn before the junction (G turn)

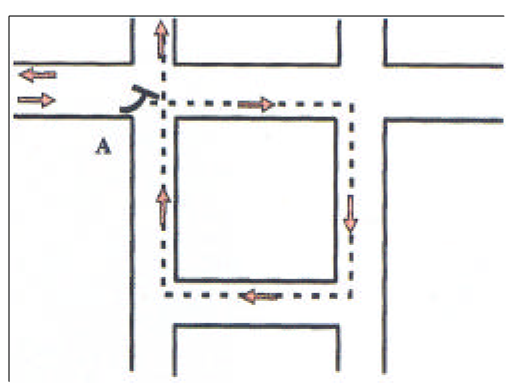


Figure 4.4 (far right): A right turn after the junction (Q turn)

to the high levels of conflicting movements and speeds. Careful geometric design of roundabouts is required to help reduce approach speeds. Research in developed countries has led to some special facilities to aid cyclists at roundabouts.

These measures are split into three types and involve either mixed flows on the roundabout itself, some physical segregation on parts of the roundabout, or a separate track for cyclists around the outside of the roundabout. Mixed flow roundabouts involve small central islands and single-lane approach roads with single-lane circulatory movement, while segregational measures reduce the risk of NMVs being hit while on the roundabout by vehicles entering the system.

Recently, moveable barriers have been provided at the Sonargaon Roundabout in Dhaka, **Bangladesh,** although their effectiveness is not yet known.

(iv) Grade-separated crossings

Some footbridges in **Indonesia** and in a number of cities in the **PRC** have been provided with a central wheeling ramp. These ramps were initially intended to aid cyclists push their machine along, although in **Indonesia**, motorcyclists were observed actually riding up and down the ramps (see Plate 5.9).

Footbridges have a lower construction cost than underpasses but are less ideal for joint cycle and pedestrian usage, generally being narrower than underpasses, thus increasing the potential for conflict. Also, the rider must dismount from the bicycle and wheel the machine up and down a smooth wheeling ramp — an unattractive procedure.

Underpasses provide grade-separated crossings of carriageways that would otherwise be too dangerous or inappropriate to cross at grade. To be well-used, underpasses, as with footbridges, need to be conveniently sited to attract high pedestrian and cyclist use. Dimensions of underpasses are important in allowing cyclists access to them and where possible, pedestrians and NMVs should be segregated in order to achieve safe access for both. Approach ramps should not be so steep that they encourage high speeds through the underpasses or to make the exit too strenuous. Underpasses with specific NMV provision are rare in the region.

c) Parking facilities

An essential part of the cycle network is the provision of cycle parking facilities to provide safe storage of the machine and reduce the threat of theft or vandalism.

Suitable facilities that fulfil these requirements involve the provision of an adequate number of cycle stands, allow either self-supplied or cycle stand provided locking mechanisms, and are located at major traffic generators, as in Surabaya, **Indonesia** (PADECO Co., Ltd.). Attendants also reduce the threat of theft. In the **Netherlands** and other developed countries, such stands are increasingly being provided with shelter from the weather. Facilities for cycle parking exist in most Asian cities where high volumes of cyclists occur (for example, cities in the **PRC** and **Viet Nam**).

Official waiting areas for cycle-rickshaws are rare and many clusters of cycle-rickshaws can be seen to be operating from various street corners and major junctions in Asian countries.

Plate 4.16 shows rickshaws waiting at the edge of the carriageway, reducing the effective carriageway width and hence the road capacity. A further problem associated with the lack of suitable parking arrangements is shown in Plate 4.17, where pedal cycles parked on the footway block pedestrian movement and force pedestrians to walk in the road.


Plate 4.16: Rickshaws parked on the side of the street due to a lack of suitable waiting bays in Yogyakarta, Indonesia.


Plate 4.17 (far right): Pedal cycles parked on the footway blocking pedestrian access in Hanoi, Viet Nam.

4.4 Integrated Programs

a) Enforcement

The enforcement of traffic regulations governing all road users and vehicles is essential for the safety of pedal cyclists and other NMVs. Regulations relating to motor vehicles that can increase road safety include the enforcement of speed restrictions and waiting restrictions in the vicinity of on-road cycle lanes. Similarly, NMV users have a responsibility to acknowledge and obey the various traffic laws. For example, NMVs should obey traffic signals, have lane discipline, and not encroach on to the footway. They should be prosecuted if they do not obey these laws.

Furthermore, it is important that pedal cycles or any NMVs are as fit for the road as any motor vehicle. Hence equipment such as reflectors, headlights, and braking systems should be fitted and in good working order. There is no reason that these should not be a legal requirement and checked for compliance. However, this is rarely done in practice.

Traffic police must treat NMVs in the same way as other road users. They should have the same rights to road space, but equally, they should have the same obligations to obey traffic laws.

Traffic regulations are not self-enforcing and it is suggested that where possible, measures be provided to ease enforcement, for example, by preventing motor vehicle access to cycle paths through bollards across the entrance and exit points.

b) Education, training and publicity

Although road safety education is part of the national school curriculum in many countries in the region, little attention or training is given to NMV users, who will often ride their machines in mixed traffic streams at a very young age with little or no knowledge of traffic regulations.

Training to increase knowledge of traffic regulations and improve cycling skills should be encouraged and should be conducted by skilled instructors. Training should include information on the correct positioning of vehicles at junctions relative to the required exit armand on the dangers of traveling along road links in the wrong direction. Publicity campaigns should be provided to educate cyclists and motor vehicle drivers about NMV safety and on-road dangers. The highway code, if it exists, should also contain a section on pedal cycle and NMV considerations.

5 MOTORCYCLES

5.1 Introduction

Motorcycles are an important part of the traffic fleet in many countries of the Asian and Pacific region and in several countries they are the dominant vehicles. Despite this importance, accident data on involvement of motorcycles in road accidents in the Asian and Pacific region is sparse. Only a few countries were able to provide the necessary breakdowns into vehicle types involved in accidents and casualties.

In addition, despite their relative importance in the traffic stream, few efforts have been made to provide special facilities to cater for the needs of motorcycles. In comparison with pedestrians, little research has been conducted into the needs of motorcycles and their road safety problems.

The authors' efforts in examining the needs, problems, and facilities of motorcycles were, therefore, characterized by lack of data and research, and the absence (apart from **Malaysia**) of efforts to provide safety facilities for these vehicles.

5.2 Motorcycle Accident and Vehicle Data

Motorcycles are involved in a substantial share of fatal and injury accidents in several countries in the region (see Tables 1.1 and 1.2).

Table 5.1 shows the extent of this involvement in fatal and injury accidents. Comparatively, motorcyclists are involved in a greater share of injury accidents than fatal accidents and in three of the countries, motorcyclists are involved in more than half of the fatal accidents.

Table 5.1: Percentage of Fatal and Injury Accidents Involving Motorcycles

Subregion	Country	Fatal accidents (percent)	Injury accidents (percent)
NIEs	**Hong Kong, China**	10	17
	Republic of Korea	7	6
	Singapore	51	69
	Taipei,China	54	62
Central Asia	**People's Republic of China** (1994)	10 (1)	na
Southeast Asia	**Malaysia** (1994)	57 (1)	74 (1)
South Asia	**Sri Lanka**	16	26
PDMCs	**Fiji** (1)	na	
Developed	**New Zealand**	16	14

na Data not available.
(1) Data relates to casualties.
Source: RETA project data.

Table 5.2: Percentage of Registered Motor Vehicles that are Motorcycles and their Rate of Growth			
Subregion	**Country**	**Percentage of motor vehicles that are motorcycles** (1993)	**Percentage change in registered motorcycles** (1989-1993)
NIEs	**Hong Kong, China**	5.3	+41
	Republic of Korea	23.6	+63
	Singapore	20.5	-1
	Taipei,China	73.7	+44
Central Asia	**People's Republic of China**	36.8	+139
Southeast Asia	**Indonesia**	68.4	+22
	Lao PDR	na	+80
	Malaysia	55.8	+30
	Philippines	25.8	+65
	Thailand	65.6	+75
	Viet Nam	na	+175
South Asia	**Bangladesh**	na	+48
	India	67.3	+60
	Pakistan	48.1	+32
	Sri Lanka	na	+68(1)
Pacific	**Tonga**	na	+45
Developed countries	**Australia**	2.8	-8
	Japan	21.0	-10
	New Zealand	na	-38

na Data not available.

(1) Growth between 1989 and 1992.

Source: RETA project data.

Table 5.2 shows the percentage of registered vehicles that are motorcycles in various countries in the region, along with the motorcycle fleet growth or decline between 1989 and 1993. An important point is that of the countries, such as **Indonesia** and the **Philippines**, that have provided motorcycle fleet information, there is no data on their involvement in accidents.

Countries with high motorcycle accident involvement rates, such as **Malaysia** and **Taipei,China**, also have large motorcycle fleets relative to the total number of motor vehicles. It should be noted that except for **Hong Kong, China,** the motorcycle share of motor vehicle traffic in the NIEs is decreasing. However, with the exception of **Singapore**, the motorcycle fleet has actually increased in size, indicating that the total number of motor vehicles has also risen but motorcycles are increasing less rapidly. In the developed countries, both the number and percentage of motorcycles, relative to the total motor vehicle fleet, have decreased steadily in recent years.

Motorcycles are a much more affordable vehicle type compared to other motor vehicles and this may lead to motorization levels increasing at an even higher rate than found in developed countries. In the most motorized country in the Asian and Pacific region — **Taipei,China** — more than 70 percent of its motor vehicles are motorcycles. Apart from the **Philippines**, two-and three-wheeled motor vehicles account for about half of all motor vehicles in the **South Asia** and **Southeast Asia** subregions. In **India**, **Indonesia,** and **Thailand**, they represent two thirds of all motor vehicles. Motor vehicle growth is expected to increase even faster than at present and with motorcycles playing a dominant role, this low-cost and vulnerable motorized vehicle could conceivably accelerate both the motorization and death rates in the Asian and Pacific region.

a) NIEs

Hong Kong, China

10 percent fatal accidents,
17 percent injury accidents

Thirty-five fatal and 2,582 injury accidents involving motorcycles occurred in Hong Kong,

China in 1993, making up 10 percent and 17 percent, respectively, of the total accidents. No obvious trend in accidents from 1989 can be seen, as fatal accidents involving motorcycles increased at the same rate as all fatal accidents. Although the number of motorcycles in Hong Kong, China has increased over time, they have not increased in number as quickly as motor vehicles and thus form a lower percentage share of vehicles.

Republic of Korea

7 percent fatal accidents,
6 percent injury accidents

In 1993, there were 673 fatal accidents and 13,912 injury accidents involving motorcycles in the Republic of Korea. There has been a decreasing trend in the number and share of both types of accident since 1989. The Republic of Korea, similar to Hong Kong, China, has a growing motorcycle fleet but a decreasing proportion of the total number of motor vehicles.

Singapore

51 percent fatal accidents,
69 percent injury accidents

Singapore had 123 fatal and 3,840 injury accidents involving motorcycles in 1993, making up 51 percent and 69 percent, respectively, of the total fatal and injury accidents. Since 1990, fatal accidents involving motorcycles have been increasing and are now at their highest level ever. This increase in fatal accidents is even more worrying when it is noted that since 1990, the motorcycle fleet in Singapore has been declining.

Taipei,China

54 percent fatal accidents,
62 percent injury accidents

Taipei,China recorded 1,125 fatal accidents and 389 injury accidents involving motorcycles in 1993, working out as 54 percent and 62 percent, respectively, of the total accidents. Taipei,China is seeing a downward trend in fatal accidents, with those involving motorcycles decreasing more rapidly. It has an increasing motorcycle fleet size that is increasing less rapidly than other types of motor vehicle.

b) Central Asia

The People's Republic of China

10 percent fatalities

The only relevant motorcycle data available for this subregion are for the PRC. Motorcycles were involved in 13 percent of all motor vehicle deaths and 10 percent of all road deaths in 1994. The PRC has also seen the number of registered motorcycles treble in size between 1989 and 1994, with an increase in the percentage share of all motor vehicles increasing from 27 percent to 40 percent. Table 5.3 shows this increase.

c) Southeast Asia

Of the seven Southeast Asian countries, some motorcycle-related data were available from all the countries, except Cambodia.

Table 5.3: Registered Motorcycles in the PRC

Year (10,000)	Motorcycles (10,000)	Motor vehicles	Motorcycles as percentage of total motor vehicles
1990	359.33	1318.53	27
1990	421.28	1,476.26	29
1991	505.15	1,657.66	30
1992	647.49	1,945.03	33
1993	858.79	2,331.64	37
1994	1,093.81	2,735.60	40

Source: RETA project data.

Indonesia

69 percent of motor vehicles are motorcycles

Registered motorcycles in Indonesia have steadily increased in number from 5.7 million in 1989 to 7.75 million in 1994 and make up 69 percent of the total motor vehicle fleet. This percentage share of the motor vehicle fleet has remained fairly constant since 1980.

Lao PDR

Motorcycle fleet doubled in five years

Motorcycle numbers in Lao PDR have more than doubled between 1989 and 1994. In 1994 there were 109,490 registered motorcycles.

Malaysia

**57 percent fatal accidents,
74 percent injury accidents**

More than half of the total road accident deaths and almost three quarters of the total injuries in 1994 in Malaysia involved motorcycles. The number of deaths and injuries involving motorcycles has increased since 1989, along with their proportional involvement in accidents, from 1,608 (43 percent) deaths in 1989 to 2,946 (57 percent) in 1994 and from 13,386 (51 percent) injuries in 1989 to 31,957 (74 percent) in 1994. During this period, the motorcycle fleet increased by 40 percent to 3.7 million registered motorcycles, which make up more than 55 percent of the total motor vehicle fleet in Malaysia.

This percentage share of all motor vehicles has remained relatively constant throughout the 1989-1993 period.

Malaysia has about 4 million registered motorcycles and their proportion on the road varies between 13 percent and 75 percent, depending on location. The motorcycle proportion of registered vehicles ranges from 36.1 percent in Kuala Lumpur to 67.1 percent in Perak.

Philippines

Motorcycle fleet doubled in six years and is now 25 percent of motor vehicle fleet

The number of motorcycles and its proportion within the motor vehicle fleet in the Philippines has increased to more than half a million in 1993, representing a doubling in fleet size since 1987.

More than a quarter of registered motor vehicles in 1993 was motorcycles.

Thailand

Motorcycle fleet doubled in five years

In 1993, more than 7.25 million motorcycles were registered in Thailand with the fleet size growing by almost 1 million from 1992.

The actual number of registered motorcycles doubled between 1988 and 1993. Motorcycles represented 64 percent of the total motor vehicle fleet in 1988 and 66 percent in 1993.

Viet Nam

Motorcycle fleet trebled in four years

The number of registered motorcycles in Viet Nam has trebled from under 1 million in 1989 to more than 3 million in 1993. A *TRR* article claims that motorcycles were involved in more than 60 percent of road accidents in Hanoi (see Bell and Kuranami, 1994).

d) South Asia

Bangladesh

**Motorcycle fleet increased by
40 percent in five years**

The number of registered motorcycles in Bangladesh has increased from 140,100 in 1989 to more than 200,000 in 1994, an increase of more than 40 percent.

India

67 percent of motor vehicles are motorcycles

There has been a constant increase in the size of the registered motorcycle fleet in India since 1980, with the fleet growing at a faster rate than other motor vehicles.

In 1993, India had about 17 million registered motorcycles, comprising more than 67 percent of total motor vehicles.

Pakistan

48 percent of motor vehicles are motorcycles

The number of motorcycles in Pakistan, along with their proportion of total motor vehicles, fluctuated between 1988 and 1993.

However, in 1993 more than 1.5 million motorcycles comprised 48 percent of the total motor vehicle fleet.

Sri Lanka

16 percent fatal accidents, 26 percent injury accidents

The number of fatal accidents involving motorcycles in 1993 in Sri Lanka was 208 (16 percent of total fatal accidents) while there were 3,610 injury accidents involving motorcycles (26 percent of total injury accidents). Between 1989 and 1993, motorcycle involvement in fatal accidents fluctuated while injury accidents showed an overall increase.

e) PDMCs

Very small percent of motorcycle accidents

Of the 11 nations in the Pacific islands, only Fiji, Samoa, and Tonga could provide any recent data involving motorcycles. A small number of fatal and injury accidents involving motorcycles has been recorded in the three countries. Samoa had 11 injury accidents involving motorcycles, which comprised 9 percent of the total injury accidents.

5.3 Motorcycle Facilities

Although few physical engineering facilities to improve motorcycle safety exist, some measures have been identified and are considered important. Motorcycle safety can be increased with the separation of two- and three-wheeled motorcycles from large, high-speed vehicles.

Plate 5.1: Segregated motorcycle lane and shared pedestrian and pedal cycle lane in the PRC.

Furthermore, motorcyclists will benefit from speed reduction measures where there is mixed traffic (see section on traffic calming and speed reduction measures in Chapter 6).

a) Road links

Increased safety can be achieved by the separation of motorcycles from other motor vehicles. This segregation can take one of two forms. Either exclusive motorcycle lanes can be created, as in **Malaysia**. These lanes are separated from the main carriageway by a physical median; or joint motorcycle and SMV lanes can be provided, as in Kuala Lumpur and **Viet Nam**. These joint lanes provide routes that pedal cyclists and other nonmotorized vehicles can also use.

The exclusive motorcycle lane in **Malaysia** is 14 km long and has led to a recorded reduction in accidents of 27 percent with a benefit to cost ratio of constructing the lane valued at about three. A subsequent extension constructed in 1992 is estimated to have reduced motorcycle accidents by 34 percent along the section of road concerned. Consequently, the exclusive motorcycle lanes in Malaysia appear to have been successful and may be worth considering in similar circumstances where high motorcycle flows are found along a corridor.

During the ADB/UN/ESCAP seminar in Bangkok (1996), some delegates expressed the view that motorcycles and pedal cycles/NMVs should be kept separate due to differences in speeds. This occurs on some roads in the **PRC** where such segregated lanes were observed to be operating (see Plate 5.1). In this instance, guardrails separate the motorcycles from a joint pedal cycle and pedestrian path, while a raised median segregates the whole path from the main carriageway.

Plates 5.2 to 5.5 show examples of shared motorcycle and pedal cycle lanes in Kuala Lumpur, **Malaysia,** and **Viet Nam**. Differences in lane width are clearly evident from the photographs; sufficient lane widths can be determined from traffic counts and forecasted flows of vehicle modes. Clear road signs for the joint use of the lane is also evident in Plate 5.5. The use of these slow moving lanes to accommodate motorcycles and pedal cycles was also being proposed as part of the Yogyakarta Master Plan in **Indonesia**. The plan included details of separate lanes of about 3.5 m to 4.5 m wide on primary collector roads.

Plate 5.2: Motorcycle and pedal cycle SMV Lane in Ho Chi Minh City, Viet Nam.

Plate 5.3 (far right): SMV Lane at a junction in Ho Chi Minh City.

Plate 5.4: Motorcycle and pedal cycle shared lanes in Kuala Lumpur, Malaysia.

Plate 5.5 (far right): Motorcycle and pedal cycle shared lanes in Kuala Lumpur. Notice the explicit signs.

Plate 5.6: Motorcyclist using main carriageway in the PRC. Note the segregated cycle lane.

Plate 5.7 (far right): Motorcyclists forced to use the main carriageway in Viet Nam.

Plate 5.8: Posts placed across a road prevent four-wheeled vehicle access in Bandung, Indonesia.

Plate 5.9 (far right): Motorcyclist using a central wheeling ramp intended for pedal cyclists on a footbridge in Jakarta, Indonesia.

Despite the provision of separate SMV lanes, in certain circumstances, the shared use by NMVs and motorcycles is generally not allowed and motorcycles must usually use the main carriageway, as shown in Plates 5.6 and 5.7.

Some motorcycle and motor vehicle separation can be achieved by allowing the shared use of bus lanes. However, full consideration of the traffic flows of both types of vehicle is important — shared use at specified times of the day could be a possible acceptable measure. Care must be taken not to encourage the sharing of all facilities such as pedal cycle

Plate 5.10: Motorcycle parking signs in Yogyakarta, Indonesia.

measures at junctions or even on footbridges, due to the differences in respective vehicle speeds. Plate 5.9 illustrates the misuse of a central cycle wheeling ramp by a motorcycle in Jakarta, **Indonesia**.

Alternative road link measures to prevent four-wheeled vehicle access were also observed in Bandung, Indonesia, where posts at the entry/exit points were used (see Plate 5.8).

b) Road surface and traffic engineering

Several Australian safety specialists have highlighted the need to give greater consideration to street maintenance and traffic engineering as these can have a serious effect on motorcycle safety.

Australia's AustRoads was planning to publish *Traffic Engineering and Motorcycle Road Safety* and Australian safety specialists suggest the following areas for consideration regarding traffic engineering and motorcycle safety.

i) **Highway geometry:** Adverse camber is especially hazardous for motorcycles because of the need to lean even further for balance. Where this occurs with uneven road surfaces or localized low friction areas of pavement it can be dangerous for motorcyclist safety.

ii) **Road surface:**

1 Manhole covers and steel plates used to cover roadworks are often extremely slippery. The application of an abrasive coating reduces the danger.

2 Speed bumps and traffic calming measures of poor design can be dangerous to motorcycles. Designs such as those advocated by TRL and the Australian Road Research Board should be used.

3 Loose gravel gets onto corners of sealed roads when shoulders are unsealed and can be dangerous to motorcyclists. At intersections on roads that have unsealed shoulders, such problems can be overcome by sealing to a curved section of kerb and gutter.

iii) **Intersections:** Motorcycles are frequently masked (hidden) by other vehicles or not noticed, so fully controlled turns should be used at signalized intersections, wherever possible, to avoid motorcycle accidents. Sharply flared intersections and small roundabouts with painted central islands can be dangerous for motorcycles. Pavement loop detectors are sometimes too insensitive (due to the light weight of motorcycles) and can fail to detect motorcycles or allow them to clear the intersection before the lights change.

iv) **Road markings:** Variations in skid resistance from road markings (for example, painted arrows, lane and edge lines, or zebra crossings) when wet or on curves can be dangerous for motorcyclists. Raised markers used to delineate lane and edge lines can also cause problems, especially at curves.

v) **Safety barriers:** Collision with a normal w-beam (Armco) steel barrier can be dangerous for motorcyclists as the rider can be catapulted over or under the barrier and reflectors on the barriers can cause injury to a rider sliding along the barrier. Wire rope barriers are particularly dangerous for motorcyclists and support posts and end treatments of all types of barriers can cause severe injury to motorcyclists. From a motorcyclist's viewpoint, the concrete tapered shape (New Jersey) barrier is probably the least damaging in the event of an accident.

vi) **Roadside furniture and objects:** Roadside vertical kerbing can cause additional dangers to motorcyclists sliding along a road after an accident unless it is of rounded semimountable design. Roadside poles, if placed too close to the kerb at corners, can be dangerous as motorcyclists have to lean over as they go round a bend.

These and other potential dangers to motorcyclists are discussed in more detail in the AustRoads document, *Traffic Engineering and*

Plate 5.11: Motorcycle parking on the footway blocking pedestrian access.

Plate 5.12 (far right): Motorcycle parking blocking a lane in the carriageway.

Motor Cycle Road Safety. What is clear is that particular care needs to be given to the design of road and traffic engineering facilities where a large number of motorcyclists can be expected in the traffic stream. Although such measures will not completely eliminate motorcycle accidents, they will minimize their occurrence and reduce their severity when they do occur.

c) Parking facilities

Parking facilities form an essential part of overall motorcycle requirements. Facilities should be well signposted and be able to cope with the expected motorcycle numbers. Where numbers of vehicles are expected to be high and where motorcycles form the largest share of all modes in traffic, special parking lots exclusively for motorcycles could be considered. Signs for motorcycle parking facilities are essential, as can be seen in Plate 5.10. Plates 5.11 and 5.12 clearly illustrate that a lack of adequate parking can cause blockages of footways and roads. Parking lots with an attendant present will help reduce the threat of theft.

5.4 Integrated Programs

Many motorcycle road safety initiatives rely not on physical engineering measures but on associated measures such as road safety education and suitable traffic regulations. These measures in the past have typically been based upon rider training and helmet legislation.

a) Enforcement

Motorcycle helmet wearing can, if correctly legislated and enforced, reduce the severity of motorcycle accidents. Legislation must provide for the compulsory wearing of helmets while riding a motorcycle of any size and speed; this must be backed by enforcement. However, helmet design and construction must relate to a suitable minimum legal standard that will offer the wearer an appropriate amount of protection in the event of an accident. Traffic police using motorcycles must be seen to wear the correct helmet type, have the helmet fastened, and to enforce their correct usage. Helmets should also be worn by pillion passengers.

Regulations concerning the size and speed of motorcycles should also be considered, along with the use of graded licenses based upon age and experience.

b) Education, training, and publicity

The training of motorcycle riders, as with any motor vehicle driver, is an important safety requirement and should be carried out by trained and qualified instructors. Training should cover information not only based on the development of driving skills and driver responsibilities, but also on safety factors such as the risk of not wearing an approved safety helmet. An official on-road riding test should be carried out in order to check the motorcyclists' competence and riding skills. Plates 5.13 and 5.14 show motorcycle training and testing in **Singapore**. Information from the 1994 *Malaysian Road Accident Statistical Report* notes that motorcycle riders were at fault in 50 percent of the accidents they were involved in and that more than 50 percent of the motorcycle riders involved in accidents were aged 16 to 25. This highlights the need for suitable training of young riders.

Potential dangers associated with motorcycle riding should be publicized (see Plate 5.15)

along with enforcement and legislation measures.

Safety publicity should be sufficiently powerful to counteract other influences presented in the mass media, including speed and glamour images that are used to advertise powerful motorcycles.

One of the most effective areas for education and publicity is to ensure the conspicuity of motorcyclists. Many accidents occur because other vehicle drivers do not see the motorcyclists. Consequently, efforts need to be made to encourage motorcyclists to increase their conspicuity.

This can be done in three main ways:

i) ride with headlights on (dipped) at all times (day and night) as this makes a motorcycle much more conspicuous to other road users;

ii) riders should wear light colored clothing and preferably reflective jackets while riding motorcycles; and

iii) use reflective strips on front and rear mudguards and along sides of the motorcycle to make it more conspicuous at night.

Plates 5.13 and 5.14: Motorcycle driver training and testing in Singapore.

Plate 5.15: Signs on the side of the road in Yogyakarta, Indonesia, promoting the use of motorcycle helmets.

6 RECENT DEVELOPMENTS

6.1 Introduction

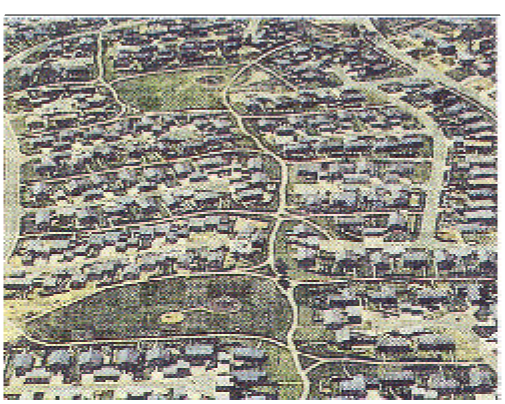
Safe planning by separating vehicles and preventing the interaction of various road users can reduce the number and severity of conflicts that occur between motor vehicles and VRUs, high-speed traffic and low-speed traffic, heavy goods vehicles, and other road users. The planning process influences safety through consideration of various components, such as land use planning, network design, and the road hierarchy.

Although the safe planning of roads is the primary step towards the prevention of conflicts, the safe design of roads through standards and specifications is also important. The design and suitable provision of the facilities relevant to VRU safety for each group are discussed in the preceeding chapters. It is intended that this section will look at those factors that are relevant to all three VRU groups together.

6.2 Land Use Planning

The control of land use and the traffic associated with the different areas of use is essential to successful planning. Incompatible traffic patterns and vehicle compositions from various land use sources should be separated in order to minimize potential conflicts. Hence, zonal planning should be considered to reduce trip lengths and to prevent VRU interactions with high speed and heavy volumes of traffic. Access control is also important in preventing inappropriate traffic mixing with VRUs.

Plate 6.1: Well-planned road network hierarchy can reduce conflicts and improve safety.



Of particular importance to VRUs is adoption of the principle of locating traffic generating facilities adjacent to a road suited to the type of traffic expected, such as the provision of coherent and linked cycle paths and footways close to a school. Furthermore, conflicts can be avoided by preventing the development of linked land use on either side of main roads; for example, schools and housing estates on opposite sides of a primary distributor road.

6.3 Road Hierarchy

The roads within a network should be defined and classified according to their function, with the network traditionally split into levels according to the primary use of the road and thus the associated traffic. VRUs should be considered within the planning and design of the network and road hierarchy in order that their own network of facilities be provided. Hence, coherent, direct, and safe routes for VRUs can be provided through measures such as linked footways, cycle lanes, and road crossing facilities.

The identification of VRU networks can allow the planning and provision of appropriate facilities where the motor vehicle and VRU networks interact. For instance, underpasses and footbridges are not necessary for local access roads; similarly no special provisions are needed for pedal cycles and other nonmotorized

Table 6.1: Pedestrian and Pedal Cycle Activity with Respect to Road Category			
Road category	Main activity	Pedestrian activity	Pedal cycle activity
Pedestrian street	Shopping, walking	Predominant	Considerable, speed limited by pedestrians
Access road	Walking, vehicle access, deliveries	Considerable freedom	Considerable, crossing, weaving, stopping
Local distributor	Start/finish of vehicle trips, bus stops	Controlled	Considerable, bicycle lane, not physically segregated, no crossing facilities
District distributor	Through traffic, public transport	Minimum positive safety measures	Considerable, segregated cycle lane, crossing facilities
Primary distributor	Fast moving, through traffic	No safety measures — segregation	Controlled, segregated cycle lane.

Source: MVA, *Beijing Traffic Study*, 1986.

vehicles on low-flow and low-speed roads. Table 6.1 shows pedestrian and pedal cycle movements in relation to the typical traffic activity on various categories of road.

Traffic management through the creation of a suitable road hierarchy and the network design can have positive effects on safety by limiting traffic levels and speeds on certain types of road, thus benefiting VRUs. Traffic management should help pedestrians and road vehicles remain on their respective facilities and to minimize their interaction. Factors such as improved traffic efficiency through reduced congestion levels and/or an improvement in the environment are also byproducts of good traffic management through suitable road hierarchy planning and design.

Appropriate planning of the road hierarchy can lead to the maximizing of priority to groups such as pedestrians and cyclists over motor vehicles. This objective is an environmental concern that restricts motor vehicle access to promote easier pedestrian and cycle use as well as general safety (see Table 6.1).

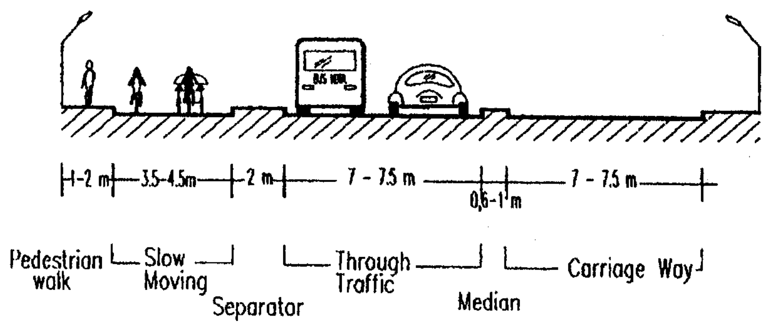
6.4 Design Standards

Design standards for VRUs should reflect the needs of each group in providing safe facilities for the movement of people and goods in order to reduce potential conflicts. However, for a facility to be fully utilized, such measures should be attractive to potential users in terms of the directness of the route. Facilities need to be coordinated and cohesive in order to maximize their potential benefit to all users while balancing the safety requirements.

The volume of VRUs within the overall traffic is an important consideration for design guidelines. In the case of NMV facilities, a separate lane for sole use of NMVs requires a width related not only to the volume of NMV traffic but also the expected NMV traffic composition.

However, it is suggested that the speed, flow, and composition of motor vehicle traffic on the road are the main factors in defining the need and type of cycle lane. Pedestrian volumes, however, are important to the level of facilities provided. Footways should cater for the expected pedestrian numbers along a route and be of sufficient width in order to prevent pedestrians having to walk on the carriageway, increasing the potential for conflict. A problem with wide footway provision is the encroachment of squatter areas, which can create hazardous conditions for all road users. In order to provide suitable facilities for VRUs, it is necessary to determine potential usage. This can be achieved only through carrying out pedestrian and traffic counts.

This volume is not intended as a design manual and although Chapters 3 to 5 provide general information on standards and capacity of different facilities, no attempt has been made to recommend specific guidelines relating to traffic volumes or other such design requirements. This document seeks only to identify facilities in use in the region, to indicate the



Source: Yogyakarta Urban Development Project, 1995.

Figure 6.1: Primary collector road through an urban area.

forms that they can take and, where possible, to comment on their perceived effectiveness.

6.5 Traffic Counts

Traffic counts along with accident recording (see below) provide the basis for designing traffic systems that cater for all road users. For example, facilities for pedal cyclists and other NMVs may depend not only on the number of pedal cycles/NMVs, but also upon the number of motor vehicles and how the two categories interact. This relates to the defining of the road hierarchy and to traffic flows within various land use zones. Traffic volumes will be highest at or near major generators and this should be considered during the planning of traffic counts.

Data in the form of vehicle and pedestrian counts can provide details of existing traffic movement, how this flow has changed over a period of time, and how it is likely to change in the future. This all helps in the design of adequate facilities to assist road users. As has been shown, only limited data exists for NMV traffic while pedestrian traffic flow is almost never counted. An informal survey carried out at the ADB/UN/ESCAP conference in Bangkok revealed that a few pedestrian counts have been carried out in Yogyakarta**, Indonesia**; Karachi, **Pakistan**; Manila, **Philippines**; and **Singapore**. Data is available for motorcycles because of their place in mainstream traffic, as well as the requirement of registering vehicles, which provides some details of ownership levels.

6.6 Accident Data Systems

Accident data provide the objective and scientific basis for determining not only the extent and type of safety problem experienced but also the kinds of remedial measures most likely to be effective. Without the collection of accident figures, the safety of a nation's road network cannot be assessed and monitored. A database consisting of relevant accident information allows an understanding of the circumstances and patterns of accidents by means of analysis. To complete the process, information from the analysis system must be disseminated to relevant organizations.

Traffic police are most ideally placed to record and manage accident data, which should include general accident details such as road type, environmental features, and location, as well as the vehicle/driver details and casualty details. Within this data collection, specific factors should be included, such as pedestrian action and location. A common accident microcomputer-based database in use is TRL's MAAP. At present in the Asian and Pacific region, it is being used in **Fiji**, **Malaysia**, **Papua New Guinea**, and **Philippines**, and in certain areas of **Bangladesh**, **India**, **Indonesia**, and **Nepal**.

A good accident reporting system is also able to investigate hazardous locations and identify any patterns or similarities between accidents. For example, MAAP has recently been introduced in Dhaka, **Bangladesh,** and despite an analysis period limited to only six months, one location in Dhaka stood out for its accident risk. On one of the main approach roads to the city, 17 road accident deaths (of which 15 were pedestrians) had occurred at the junction.

After identifying what could, with justification, be called the world's worst black spot, the accident analysis program can also check for similarities in accident timings, vehicle maneuvers, and other factors such as vehicle types involved.

The accident statistics presented in the previous chapters give some indication of the low priority being given to VRU safety in the Asian and Pacific region. Many countries appear not to be monitoring VRU accidents, or at least not publicizing data findings. According to the UN/ESCAP survey, while accident data are centrally stored in 13 of the 15 respondent countries, only seven countries use microcomputers for accident data storage and four countries use mainframes.

Meanwhile, paper files (i.e., manual analysis) are still largely used in five countries, including **Bangladesh**, **India**, **Indonesia, Nepal**, and **Sri Lanka** (some of these countries, however, do have the MAAP system in use on a pilot basis or running in parts of the country).

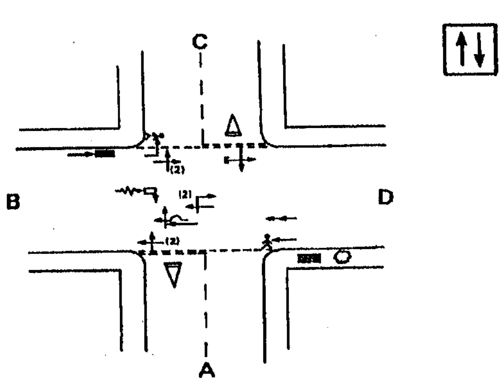


Figure 6.2: Collision diagram.

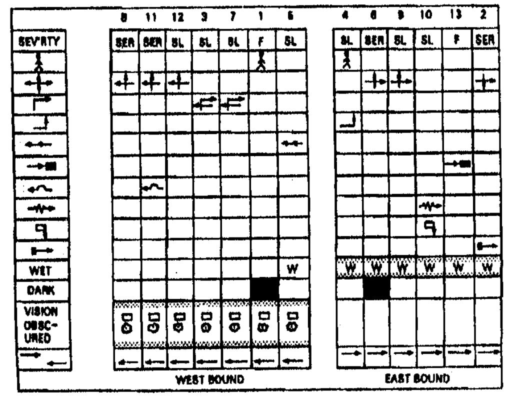


Figure 6.3 (far right): Accident factor grid.

6.7 Foreign Aid Projects

Until recently, foreign funded road and transport improvement projects traditionally had a narrow focus, being concerned primarily with maximizing traffic efficiency along all road links. However, in recent years there has been growing attention paid to the safety problem, environmental issues, and social impact created during the design of new transport infrastructure. While VRU requirements have begun to be addressed, the true impact of recent transport developments on VRUs safety and activity is still largely unknown due to the lack of information on accident involvement rates and the volumes within the traffic flow. This lack of knowledge has contributed in the past to the lack of VRU consideration in the design and construction of many projects.

6.8 Traffic Calming and Speed Reduction Measures

In the past decade, two key road safety engineering ideas have been developed and implemented in **Europe** and other motorized countries. These two developments were traffic calming and safety audits, both of which have been credited with achieving accident reductions, and improving environmental quality and avoiding expensive construction modification costs.

Traffic calming (where engineering measures are used to reduce speed and volume of motor vehicle traffic) has proven successful in developed countries. Not only is the risk of accidents reduced but also the associated accident severity. These benefits apply to all road user groups with the creation of a better environment, but are particularly beneficial to the safety of pedestrians, pedal cycles, and other nonmotorized vehicles. Traffic calming methods involve the horizontal and vertical realignment of roads at selected locations using various methods, such as road humps and speed tables, chicanes, pinch points, and footway widening. Alterations can also be applied to junctions by raising the whole junction layout, providing entry treatments across junctions and the use of miniroundabouts to help control speeds. Such measures should be implemented as part of an area-wide set of measures.

The benefits from speed reduction have received much attention in recent years and an international review of speed and accidents concluded that, on average, each one mile per hour (mph) (1.6 km/h) reduction in speed would result in a 7 percent reduction in fatal accidents. Another finding, which has been used extensively in publicity campaigns, is the effect of speed on pedestrian casualty severity. At 20 mph (32 km/h), 5 percent of pedestrians hit will die compared to 85 percent at 40 mph (64 km/h) (while 95 percent of children hit at 40 mph will die).

As traffic calming is meant to benefit a wider ranging group by reducing vehicle speeds and volumes, specific measures for NMVs are not necessary, providing that their needs are fully considered during the planning stage. For instance, where carriageway widths have been reduced, the interaction of cyclists and motor vehicles in the remaining space is of prime concern. Facilities for cyclists to avoid or minimize the effects of physical obstacles meant for high-speed vehicles should be considered and catered for wherever possible. The design and construction of traffic calming features can have a significant impact upon cycle use; this includes construction features such as smooth transition between running surfaces. Inappropriate measures, such as rumble strips, should be avoided because of the discomfort caused to NMV users, or else the design should be such that it has minimal effect on NMV traffic.

Plate 6.2 (above): Traffic calming in Tokyo, Japan.

Plate 6.3 (right): Town center traffic calming in the UK.

Traffic calming is beginning to be applied in the developing countries of the Asian and Pacific region. In **Nepal**, village gateways and two armed roundabouts have been suggested for restraining speeds on highways traversing villages. After being upgraded, highways generally experience higher speeds and increased accidents. In order to control speeds where the road passes through an inhabited area, village gateways have been recommended with a signposted village archway and heavy vegetation planted on the sides of the signs, and with the added effect of rumble bars increasing in height. If these measures do not prove effective, then the more costly option of a two-armed roundabout will be considered. **Fiji** has for several years been implementing traffic calming measures on main roads as they pass through villages. Village gateways have been installed at several locations. Such measures have also been proposed for **Samoa**.

In an attempt to bring consistency to the various local schemes, traffic calming design criteria have been recently developed in **South Africa**. The 16 criteria include traffic volumes, accident rate, public service vehicles, pedestrian risk, 85th percentile speed, through traffic volumes, pedestrian volumes, parking/loading movements, schools/playgrounds, footway/verges, frontage/accesses spacing, sensitive area, one- or two-way, stopping sight distance, gradient, and road type. The two pedestrian specific factors are pedestrian risk, which is a subjective assessment of risk exposure, and pedestrian volumes, which is the total pedestrian movement over a four-hour period along a 150 m section. There are no specific NMV or motorcycle criteria as these are not major modes in South Africa. The criteria are weighted with only the speed factor receiving the highest weighting level (five) while pedestrian risk is weighted at two and pedestrian volumes at three. Guidance on safety-conscious planning and design of road networks, and checklists for safety checking of roads are provided in the TRL document *Towards Safer Roads in Developing Countries* (see Ross, et al., 1991).

6.9 Safety Audit

Safety audit refers to the formal process of reviewing road projects specifically to identify potential or existing safety hazards in order to allow for timely proactive correction, especially for pedestrians and other VRUs whose safety needs are often neglected in traditional transport planning and design.

Plate 6.4: Raised pedestrian crossing in Fiji.

Plate 6.5 : Gateway in Fiji.

Safety checking or safety auditing (which is a more formalized process) offer opportunities to create safer roads for vulnerable road users.

Audits on road schemes can be carried out with specific reference to any of the vulnerable road user needs before a formal safety audit. In developed countries, audits of cycle routes are becoming the norm.

The elements that can be checked at various stages for each VRU are shown in Table 6.2. It should be noted that these considerations are factors within the overall full formal safety audit.

Nine of the 15 countries responding to the Road Engineering/Safety Infrastructure section of the UN/ESCAP survey claimed to have conducted safety audits or safety checks before construction and the **Republic of Korea** reported that its safety experts commented on schemes, although not as part of formal road safety audits.

The extent to which these safety audits exist in practice is not known. The only verified safety audit procedures are from **Fiji**, **Nepal** (where a draft *Road Safety Audit Manual* has recently been produced and includes a sample audit), and **Papua New Guinea**, where safety audit procedures have been introduced as part of recently completed ADB-funded safety projects.

The Department of Roads in **Nepal** recently began requiring all major new road projects to undergo a road safety audit. The key principles of the road safety audit process in Nepal include:

- designing for all road users; and
- encouraging appropriate speeds and behavior by design (Transport Engineering and Safety Unit [TESU], 1996).

The first principle refers to the break with traditional road engineering's focus on pavement design and four-wheel motorized vehicles, and ensuring that all road users' needs are considered in the design process. The second VRU-related principle given is to ensure appropriate speed through good design. For example, when major national roads pass through small communities or towns, speeds that were perfectly acceptable on the rural sections of the roads will no longer be appropriate. Thus, through design, drivers have to be made to realize that they are entering a different "zone" where high speed is no longer acceptable. Use of such features as rumble strips and gateway features as motorists approach communities give a clear indication of a change in road character and this should result in reduced speed as motorists pass through the community.

Table 6.2: Safety Audit Considerations for VRUs			
Audit stage	**Vulnerable Road User Design Considerations**		
	Pedestrian	**Nonmotorized vehicle**	**Motorcycle**
Feasibility	Impact of road improvements in area of high activity. Severance of existing route. Expected flows — along and across the road. Pedestrian provisions — footway and crossings. Accident data for similar schemes.	Impact of road improvements in area of high activity. Severance of existing route. Expected flow on/across the road. Cycle lanes/crossings. Accident data for similar schemes. Junction numbers minimized and of correct type.	Scheme consistent with adjacent road standards. Severance of existing two-wheel vehicle route.
Preliminary design	Establish sightline design standards. Adequate footpath provision. Crossing provisions at major/minor junctions and traffic signals. Suitable crossing locations and types.	Establish sightline design standards. Merging/diverging areas with motor vehicles. Crossing facilities. Suitable junction types and size considered re. movements. Adequate cycle path provision.	Suitability of separate lanes — merging/diverging locations, sightlines, and speeds.
Final design	Signs/markings/street furniture — correct position, conspicuity and visibility. Adequate footway provision with cohesive/direct routes. Pedestrian guardrail provision and location. Landscaping effect on visibility. Correct materials specified. Lighting requirements. Approach speeds of vehicles at crossing locations. Dropped kerbing suitability. Zebra, pelican crossings and pedestrian phase at signal junctions — signal heads visible, central refuge, signal timings, and banned turns, pedestrian visibility to drivers. Refuges — size, visibility, location; overtaking prevented.	Signs/markings/street furniture — correct position, conspicuity and visibility. Landscaping effect on visibility. Correct materials specified. Lighting requirements. Approach speeds of vehicles at crossing locations. Dropped kerbing. Turning conflicts at junctions minimized. Roundabout approaches/ circulatory lanes. Overtaking at refuges prevented. Cycle crossings provided. Adequate and suitable cycle path provisions and dimensions. Traffic regulations to ban waiting vehicles on lanes.	Signs/markings/street furniture — correct position, conspicuity, and visibility. Landscaping effect on visibility. Advancing warning of crossings. Turning conflicts at junctions minimized. Motorcycle paths of suitable design standard. Traffic regulations to allow specified access.
Pre-opening	Adequate footway provisions. Footways connected — direct, cohesive safe routes. Signs and guardrails checked. Route should be walked, cycled, and driven along during the day and night.	Cycle paths of adequate dimensions and linked. Smooth transitions between riding surfaces. Route should be walked, cycled, and driven along during the day and night. Publicize that path exists.	Motorcycle paths of adequate dimensions and fulfilling design standards. Smooth transitions between riding surfaces. Route should be walked, cycled, and driven along during the day and night.

7 CONCLUSIONS

Although pedestrians are the largest casualty group involved in road accidents in most Asian and Pacific countries, motorcycle accidents have become, or are rapidly becoming, a serious problem. Pedal cycles and other NMVs, however, according to the national statistics of most countries, seem to contribute far less to road accidents than their presence in the traffic stream would suggest. Conflicting evidence, though, from Beijing, **PRC**, shows that they are involved in a high proportion of road accidents in that city. These three groups together are often involved in more than 75 percent of all fatal and injury accidents in much of the region.

Despite the extensive presence of pedestrians, pedal cycles, NMVs, and motorcycles in the traffic stream, there is a considerable lack of information regarding the proportion and usage of these modes and their importance with respect to road accidents in many countries. The lack of comprehensive accident data systems, coupled with the underreporting of many accidents, prevents detailed analysis from being carried out and thus the most suitable remedial measures cannot necessarily be implemented, be they engineering, enforcement, or education. An efficient accident data system that collects accident details, such as VRU actions, age and sex, as well as the accident locations, needs to be implemented as a matter of priority in countries where it is missing.

Motor vehicle growth in the region is between about 16 percent and 18 percent, and it is feasible that this rate could increase since the number of motorcycles is increasing more rapidly than other types of motor vehicle in many countries. This situation is compounded by many governments appearing to be actively discriminating against NMVs with policies designed to discourage their use. The increase in the proportion of motorcycle traffic may have a significant detrimental impact on future accident rates.

In the Asian and Pacific region, there is a severe lack of priority and attention given to VRU movements, despite VRUs dominating travel patterns and casualty types. While some consideration has been given to pedestrians' needs, especially as they cross roads and come into direct conflict with vehicle flows, NMVs and motorcycles are left to manage in the general traffic stream alongside larger and faster motor vehicles. It may be unreasonable to expect NMV policy or geometric design standards to be radically revised so as to reflect a more balanced approach towards the different travel modes, but much more could be done to improve road safety and facilities for such groups.

More attention should be given to VRUs through improved land use planning and road hierarchy. This is justified both by their volume as well as their vulnerability. A better approach to VRUs (especially pedestrians and NMVs) includes considering their needs at the earliest planning stages instead of the traditional traffic engineering focus on four-wheel motor vehicle traffic. Land use planning can minimize trip lengths and frequencies while a well-designed road hierarchy would match trip types to road classes, thereby reducing the conflict between such different modes as pedestrians, cyclists, private cars, and large commercial vehicles.

A practical and realistic approach to improving VRU safety is needed. Road user conditions vary so much from that of developed countries that many of the measures and assumptions used in the developed world do not apply for the developing Asian and Pacific region. What has been learned from the review

of VRU safety presented here is the lack of any simple and effective measures that are uniformly successful across the region. Even facilities tailored to local conditions can have difficulties. For instance, raised zebra crossings may have insufficient impact on driver compliance (even with high humps), 1.5 m guardrails may still be climbed, and the level of enforcement needed to ensure proper use of facilities provided may well be missing.

None of the above changes or reduces the need for improving VRU safety. It does, however, support the case for the development of low-cost measures that can be widely implemented and field-tested. It is recommended that the following strategy be considered for the development of VRU facilities and the improvement of VRU safety.

Immediate Action

i. Scarce resources dictate that the priority focus should be on known VRU problem areas, such as junctions for NMVs and motorcyclists, and mid-link crossings for pedestrians. Conflict areas need to be addressed in a realistic and pragmatic manner. For instance, no priority should be assigned to VRU facilities unless it can be enforced; i.e., at-grade zebra crossings should not be used as they can offer only a misleading sense of priority and a false sense of security unless there is a willingness to enforce driver observance.

ii. On primary roads, NMV turns may need to be banned as part of a general traffic rule to ensure NMVs remain in the slow lane and do not conflict with faster motorized vehicle flows. However, in order to ensure a reasonable level of compliance, attractive traffic management alternatives such as G turns and Q turns need to be provided to prevent NMVs from making the particular banned turn.

iii. VRU-friendly design should be sought with wider and flat-topped medians used. Refuges can also be provided and dropped edge detail could be suitable for NMV usage.

iv. As VRU safety is insufficiently catered for in traditional road engineering, safety audits should be used to double-check all proposed schemes for their impacts on VRU safety and to ensure that NMV traffic movements can be undertaken safely.

v. Traffic calming measures should be introduced in urban and rural locations to ensure speed is at an appropriate level for the road, and its traffic and surrounding land use.

vi. Research should be undertaken to develop and assess facilities to improve VRU safety.

Longer-term Action

Over time, VRU consideration should be incorporated into the planning stage. A well-defined road hierarchy would assist, as VRUs would receive priority on the lower category roads and a NMV network could be developed. An approach based solely on improvement of isolated black spots is insufficient and needs to be extended to development of safe networks for NMV use.

While land use planning and a road classification system will help minimize conflicts between VRUs and motorized four-wheeled vehicles, VRU movements and flows will continue to dominate traffic flows and increased funding will be needed to provide VRU facilities.

Finally, two main points need to be stressed:

i. The trade-off between convenience and safety prevents any engineering measure from being automatically assumed to be successful. VRU facilities should always be monitored in order to identify which locations are operating successfully and where modifications are needed to facilities not functioning properly. Over time, a better understanding should evolve of the factors needed to improve VRU safety.

ii. While improved and increased VRU facilities are a prerequisite to VRU safety, they cannot be expected to improve VRU safety on their own. Enforcement, and education and publicity campaigns are needed to motivate proper road use behavior from all modes. Enforcement and publicity campaigns should be designed and timed to complement and coincide with engineering improvement measures.

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