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REAAA Technical Report

Compendium on Good Practices: Road Safety – Make it Happen

Jamilah Mohd Marjan, MIROS, Malaysia
Kieran Sharp, ARRB Group, Australia
Ahmad Farhan Mohd Sadullah, MIROS, Malaysia
Blair Turner, ARRB Group, Australia

Advisory Group on Good Practices:
Road Safety – Make it Happen

on behalf of REAAA Technical Committee

REAAA Technical Report TC-4

REAAA Project: Road Safety – Make it Happen

REAAA Technical Report TC-4 – February 2013

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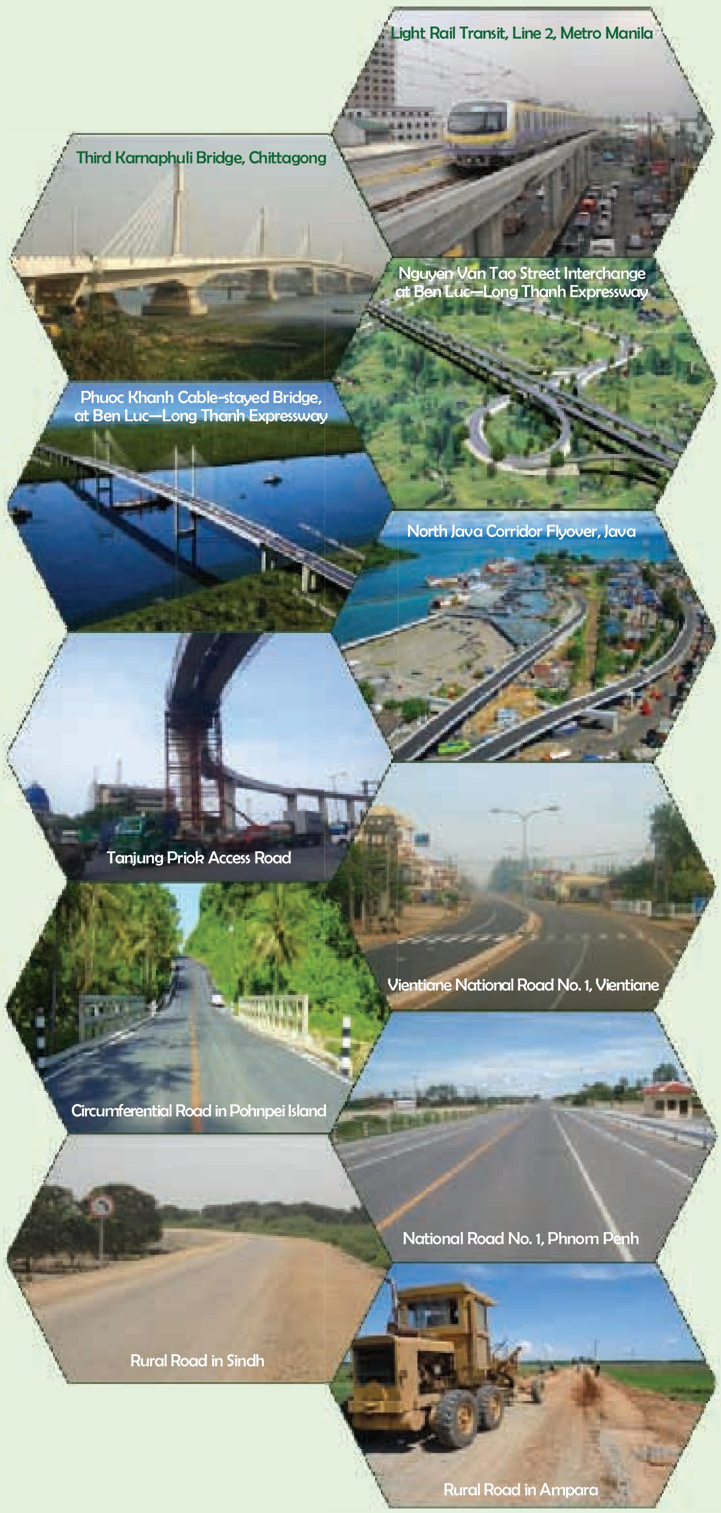

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Advisory Group on Good Practices: Road Safety – Make it Happen

Prepared by

Jamilah Mohd Marjan, MIROS, Malaysia,
Kieran Sharp, ARRB Group, Australia
Ahmad Farhan Mohd Sadullah, MIROS, Malaysia
Blair Turner, ARRB Group, Australia

Published by REAAA
46B Jalan Bola Tampar 13/14
Section 13
40100 Shah Alam
Selangor, Malaysia
Phone: +603 553 6380
Fax: +603 553 9390
E-mail: reaaa@po.jaring.my
www.reaaa.net

COMPENDIUM ON GOOD PRACTICES: ROAD SAFETY – MAKE IT HAPPEN

REAAA

Kuala Lumpur, Malaysia

REAAA Profile

REAAA is the Road Engineering Association of Asia and Australasia. The association promotes the science and practice of road engineering and related professions in the Asia Pacific region through the development of professional and commercial links within and between countries in the region.

REAAA was set up in June 1973 with a permanent secretariat in Malaysia. It has more than 1,500 members in 37 countries. It holds regular events including an annual heads of road authorities (HORA) meeting, a triennial international conference, technical visits and study tours, trade exhibitions, seminars, forums and workshops. It also publishes a Journal twice a year and a regular Newsletter.

Local REAAA Chapters have been set up in Australia, Brunei, Korea, Malaysia, New Zealand and the Philippines. REAAA is also active in Indonesia, Japan, Papua New Guinea, the Pacific Islands, Singapore, Taiwan, Thailand and Vietnam.

Membership of Advisory Group: Road Safety – Make it Happen

Country	Name	Organisation	E-Mail Address
Australia	Mr Blair Turner Mr Kieran Sharp	ARRB Group ARRB Group	blair.turner@arrb.com.au kieran.sharp@arrb.com.au
Brunei	Mr Rafitra Razak	Public Works Department	rafroads@yahoo.com
Indonesia	Dr Didik Rudjito	Indonesian Road Development Association	didik_rudjito@yahoo.co.uk
Japan	Mr Yoshiharu Namikawa	National Institute for Land and Infrastructure Management	namikawa-y92di@nilim.go.jp
Korea	Mr Jeong-Gyu Kang	Korea Expressway Corporation	kangsan@ex.co.kr
Malaysia	Dr Jamilah Mohd Marjan Prof Ahmad Farhan Mohd Sadullah	MIROS MIROS[1]	jamilah@miros.gov.my cefrhn@eng.usm.my
New Zealand	Mr Colin Brodie	NZ Transport Agency	colin.brodie@nzta.govt.nz
Philippines	Mr Philip F Menez	Department of Public Works & Highways	noemi_reaaaphil@gmail.com
Singapore	Mr Ho Seng Tim	Land Transport Authority	seng_tim_ho@lta.gov.sg
Taiwan	Mr Kai-Kuo Chang	Institute of Transportation	kaikuo@iot.gov.tw
Thailand	Dr Ponlathep Lertworawanich	Department of Highways	ponla.le@doh.go.th

1. Now Universiti Sains Malaysia (USM).

SUMMARY

Each year nearly 1.3 million people (or 3,000 people each day) die as a result of a road traffic collision and more than half of these people are not travelling in a car. Twenty to fifty million more people sustain non-fatal injuries, a major cause of disability worldwide. Ninety per cent of road traffic deaths occur in low- and middle-income countries, which account for less than half the world's registered vehicle fleet. Road traffic injuries are among the three leading causes of death for people between 5 and 44 years of age. Unless immediate and effective action is taken, road traffic injuries are predicted to become the fifth leading cause of death in the world, causing an estimated 2.4 million deaths each year.

REAAA Governing Council agreed that the development of a *Compendium on Good Practices: Road Safety – Make it Happen* would be one way for REAAA to make a positive response to this global challenge. As a result, a workshop addressing this topic was conducted during the 9th Heads of Road Authorities (HORA) meeting, held in Kuala Lumpur in April 2010. The outcome of this workshop was a Table of Contents and a work program for the delivery of the Compendium.

This *Compendium on Good Practices: Road Safety – Make it Happen* commences with an overview of the Decade of Action (2011-2020). This is followed by a compilation of accident statistics for each country in the region commencing from the year 2001 up to, depending on the availability of data, 2010 (2011 data is available from Indonesia).

A series of case studies addressing the issues identified during the workshop as relevant to the topic is then presented. Each country was asked to address two or three of these issues and the resulting responses have been condensed into this Compendium.

ACKNOWLEDGEMENTS

The authors acknowledge all those who participated in the preparation of the case studies and the Working Group for their contributions to the preparation of this Compendium.

Currency Conversion Rates

As at 31 January 2013, the currency conversion rates compared to the USD were as follows (conversion rates obviously vary over time):

1 USD ≈	0.96 AUD	Australia
	1.24 BND	Brunei
	0.74 EUR	Euro
	9,685 IDR	Indonesia
	90.9 JPY	Japan
	1,090 KRW	Korea
	3.11 MYR	Malaysia
	1.20 NZD	New Zealand
	40.7 PHP	Philippines
	1.24 SGD	Singapore
	29.6 TWD	Taiwan
	29.8 THB	Thailand
	20,820 VND	Vietnam

CONTENTS

FIGURES

TABLES

1 INTRODUCTION

Each year nearly 1.3 million people (or 3,000 people each day) die as a result of a road traffic collision and more than half of these people are not travelling in a car. Twenty to fifty million more people sustain non-fatal injuries, a major cause of disability worldwide. Ninety per cent of road traffic deaths occur in low- and middle-income countries, which account for less than half the world's registered vehicle fleet. Road traffic injuries are among the three leading causes of death for people between 5 and 44 years of age. Unless immediate and effective action is taken, road traffic injuries are predicted to become the fifth leading cause of death in the world, causing an estimated 2.4 million deaths each year. This is, in part, a result of rapid increases in motorisation without sufficient improvement in road safety strategies and land use planning. The economic consequences of motor vehicle crashes have been estimated at being between 1% and 3% of the respective GNP of the world's countries, a total of over $500 billion. Reducing road casualties and fatalities will reduce suffering, promote growth and free resources for more productive use.

In response to this issue, the United Nations (UN) General Assembly Resolution 64/255[1] of March 2010 proclaimed 2011–2020 the *Decade of Action for Road Safety*, with a global goal of stabilizing and then reducing the forecasted level of global road fatalities by increasing activities conducted at the national, regional and global levels.

Resolution 64/255 requested the World Health Organization (WHO) and the UN Regional Commissions, in cooperation with the UN Road Safety Collaboration and other stakeholders, to prepare a *Global Plan of Action for the Decade of Action for Road Safety 2011-2020* (United Nations 2010) as a guiding document to support the implementation of its objectives. In addition, Resolution 64/255 invited WHO and the UN regional commissions to coordinate regular monitoring, within the framework of the UN Road Safety Collaboration, of global progress towards meeting the targets identified in the Plan of Action through global status reports on road safety and other appropriate monitoring tools.

The Plan is intended as a guiding document for countries, at the same time for facilitating coordinated and concerted action towards the achievement of the goal and objectives of the *Decade of Action for Road Safety 2011–2020*. It provides a context that explains the background and reasons behind the declaration of a Decade by the UN General Assembly. This global Plan serves as a tool to support the development of national and local plans of action, while simultaneously providing a framework to allow coordinated activities at regional and global levels. It is directed at a broad audience including national and local governments, civil society and private companies willing to harmonise their activities towards reaching the common objective while remaining generic and flexible to country needs.

REAAA Governing Council agreed that the development of a *Compendium on Good Practices: Road Safety – Make it Happen* would be one way for REAAA to make a positive response to this global challenge.

As a result, a workshop addressing this topic was conducted during the 9th Heads of Road Authorities (HORA) meeting, held in Kuala Lumpur in April 2010. The outcome of this workshop was a Table of Contents and a work program for the delivery of the Compendium.

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1 http://www.who.int/violence_injury_prevention/publications/road_traffic/UN_GA_resolution-54-255-en.pdf.

2 In some cases, data for 2010 was not available whilst data for 2011 was available from Indonesia.

A series of case studies addressing the issues identified during the workshop as relevant to the topic is then presented.

1.1 Format of Case Studies

In establishing the topics to be addressed in the Compendium, members were sent a list of possible topics and asked to rank each topic in terms of importance (5 = highest; 0 = lowest). The list was not intended to be exhaustive or limiting and members were free to suggest other topics which could be addressed in the Compendium.

Following discussion at the Workshop, the final topics to be addressed in the case studies were agreed to. Each member country was asked to select a minimum of three topics and to prepare case studies addressing their selected topics.

The final agreed topics were as follows:

- mixed traffic/segregation of motorcycles
- vulnerable road users: pedestrians and cyclists
- optimization of road operations
  - optimization of intersections
  - speed management
- road hierarchy
- maintenance issues
- road design
- non-engineering issues.

It was also agreed that, ideally, the following general issues should be addressed in each case study:

- specific intervention/regional intervention
- intended outcome of the intervention
- effect of the implementation of the intervention (success or failure)
- description, photos, evidence, after study
- results and evidence
- costs and returns.

Reference

United Nations 2010, Global Plan for the Decade of Action for Road Safety 2011-2020.

2 DECADE OF ACTION (2011-2020)

The UN Road Safety Collaboration has developed a Global Plan for the Decade of Action for Road Safety 2011-2020 with input from many partners through an extensive consultation process.

The overall goal of the Decade of Action is to stabilise and then reduce the forecast level of road traffic fatalities around the world by 2020. This will be attained through:

- adhering to and fully implementing the major UN road safety related agreements and conventions, and use others as principles for promoting regional agreements and conventions, as appropriate
- developing and implementing sustainable road safety strategies and programs
- setting an ambitious yet feasible target for a reduction of road fatalities by 2020 by building on the existing frameworks of regional casualty targets
- strengthening the management infrastructure and capacity for the technical implementation of road safety activities at the national, regional and global levels
- improving the quality of data collection at the national, regional and global levels
- monitoring progress and performance on a number of predefined indicators at the national, regional and global levels
- encouraging increased funding to road safety and the better use of existing resources, including through ensuring a road safety component within road infrastructure projects
- building capacities the at national, regional and international level to address road safety.

Activities over the *Decade of Action* should take place at the local, national, regional and global levels, but the focus will primarily be on national and local level actions. Within the legal constructs of national and local governments, countries are encouraged to implement activities according to the following five pillars, based on the recommendations of the *World Report on Road Traffic Injury Prevention* (World Health Organization 2004) and proposed by the Commission for Global Road Safety:

- building road safety management capacity
- improving the safety of road infrastructure and broader transport networks
- further developing the safety of vehicles
- enhancing the behaviour of road users
- and improving post-crash care.

The pillars, and related activities, are described in more detail in United Nations (2010). A brief summary of the five pillars is presented in Appendix A.

Countries should consider these five areas within the framework of their own national road safety strategy, capacity and data collection systems. For some countries an incremental approach to including all five pillars will be required.

National Activities				
Pillar 1 **Road safety management**	**Pillar 2** **Safer roads and mobility**	**Pillar 3** **Safer vehicles**	**Pillar 4** **Safer road users**	**Pillar 5** **Post-crash response**
International Coordination of Activities				

In terms of the road infrastructure, the pillars of influence can be interpreted as follows:

- promote safety in road design and network management
- use road infrastructure assessment and improved design to raise the inherent safety and proactive quality of road networks for the benefit of all road users
- review opportunities for improved safety in the planning, design, construction, operation and maintenance of road infrastructure projects through:
    - the identification of opportunities for safety improvement
    - pro-active and reactive measures backed by research and evaluation
    - the implementation of safety improvement measures using a systematic approach supported by evaluation.

Reference

World Health Organization 2004, World report on road traffic injury prevention, Edited by M Peden, R Scurfield, D Sleet, D Mohan, AA Hyder, E Jarawan & C Mathers, WHO: Geneva.

3 THE 'SAFE SYSTEM' APPROACH

The Safe System approach represents a significant change in the way that road safety is managed and delivered. The approach recognises that humans, as road users, are fallible and will continue to make mistakes. In addition, humans are physically vulnerable, and are only able to withstand limited kinetic energy exchange (e.g. during the rapid deceleration associated with a crash) before serious injury or death occurs. Infrastructure is required that takes account of these errors and vulnerabilities so that road users are able to avoid serious injury or death in the event of a crash. Safe System principles aim to manage vehicles, roads and roadside infrastructure, and speeds to eliminate death and serious injury as a consequence of a road crash.

The Safe System approach reflects a holistic view of the combined factors involved in road safety. It protects responsible road users from death and serious injury by taking human error and frailty into account. It has four essential elements:

- alert and compliant road users
- safe roads and roadsides
- safe speeds
- safe vehicles.

Management of speed is a core feature of the Safe System approach. Human tolerances need to be considered in the setting of speed limits so that, in the event of a crash, the chances of road users being killed or seriously injured are minimised. For example, in collisions between cars and pedestrians, the chance of survival decreases dramatically above speeds of around 30 km/h. Unless adequate infrastructure is provided (such as separation of cars and pedestrians), speeds need to be below this level to ensure survival in the event of a crash. Similar critical speeds exist for side collisions (e.g. at intersections) between cars (50 km/h) and head-on crashes (70 km/h). To prevent death or serious injury involving these crash types, infrastructure must be provided to minimise the chance of a crash, or the severity if a crash does occur, or the speed must be below these levels.

The Safe System approach is based primarily on the Swedish 'Vision Zero', and the Dutch 'Sustainable Safety' approaches. Vision Zero suggests that it is not acceptable for fatal or serious injuries to occur on the road system, and that account must be taken of human tolerances when designing road infrastructure (e.g. Tingvall 1998). The Sustainable Safety approach (Wegman and Aarts 2006) is based on the following concepts, the first four of which relate most directly to road infrastructure improvements and road use management:

- Functionality: roads should be differentiated by their function:
    - through roads which are designed for travel over long distances (typically at high speed, ideally on a motorway)
    - distributor roads which serve districts, regions and suburbs
    - local roads, which allow access to properties.
- Homogeneity: differences in vehicle speeds, direction of travel and mass on specific roads should be minimised.
- Predictability: the function and rules of a road should be clear to all road users; this approach has led to the development of the 'self-explaining road' (e.g. Theeuwes and Godthelp 1992).
- Forgivingness: roads and roadsides should be forgiving to road users in the event of an error.
- State awareness: road users should be able to assess their capability of handling the driving task.

References

Theeuwes, J & Godthelp, H 1992, Self-explaining roads. Proceedings of the first world congress on safety of transportation, Delft, the Netherlands.

Tingvall, C 1998, The Swedish 'Vision Zero' and how parliamentary approval was obtained, Road Safety Research, Policing, Education Conference, Wellington, New Zealand.

Wegman, F & Aarts, L (eds.) 2006, Advancing sustainable safety: National Road Safety Outlook for 2005-2020, SWOV Institute for Road Safety Research. http://www.swov.nl/rapport/DMDV/Advancing_Sustainable_Safety.pdf, viewed 8 December 2006.

4 CURRENT ACCIDENT STATISTICS

Each country was asked to provide accident statistics commencing from the year 2001 up to, depending on the availability of data, 2010 (2011 data is available from Indonesia). The following information was requested:

- number of fatalities (within 30 days of the occurrence of the accident)
- number of seriously injured road users
- number of slightly injured road users
- population
- number of registered vehicles.

It was recognised that definitions varied between countries. However, it was generally agreed that, if possible:

- a 'fatality' would be a death within 30 days of the occurrence of the accident
- a 'seriously injured road user' would be any person injured who was hospitalised for a period of more than 24 hours.

Respondents were asked to provide additional footnotes if different definitions were used and/or if other relevant information was available.

This is followed by a compilation of accident statistics for each country in the region commencing from the year 2001 up to, depending on the availability of data, 2010 (2011 data is available from Indonesia)

The information provided by members follows.

Country: **Australia**
Agency Reporting: **ARRB Group Ltd**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	% change: 2010–2001
Fatalities[1] (number)	1,737	1,715	1,621	1,583	1,627	1,602	1,603	1,465	1,492	1,367	–21.3
Seriously injured road users[2]	27,471	27,934	28,422	28,864	30,574	32,264	–	–	–	–	
Slightly injured road users	–	–	–	–	–	–	–	–	–		
Population	19,413,000	19,651,000	19,895,000	20,127,000	20,395,000	20,698,000	21,015,000	21,374,000	21,955,000	22,342,000	+15.8
Registered vehicles	12,477,000	12,822,000	13,163,000	13,533,000	13,920,000	14,359,000	14,780,000	15,297,000	15,670,000	16,061,000	+28.7
Fatalities/10,000 registered vehicles	1.4	1.3	1.2	1.2	1.2	1.1	1.1	1.0	1.0	0.9	–35.7

1 Fatality within 30 days of the accident.

2 Admitted to hospital including same day discharge.

Country: **Brunei Darussalam**
Agency Reporting: **Department of Roads, Public Works Department, Brunei Darussalam**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	% change: 2010–2001
Fatalities[1] (number)	45	40	30	36	38	32	54	29	38	26	–42.2
Seriously injured road users[2]	55	70	70	88	64	49	74	57	71	74	+34.5
Slightly injured road users	480	485	575	532	465	506	482	458	536	624	+23.1
Population	340,918	348,248	355,509	362,769	370,075	377,442	384,852	392,280	399,687	414,400	+21.6
Registered vehicles	133,494	144,582	158,713	166,674	169,789	168,849	180,492	145,907	126,797	129,687	+2.9
Fatalities/10,000 registered vehicles	3.4	2.8	1.9	2.2	2.2	1.9	3.0	2.0	3.0	2.0	–41.2

1 Fatality within 30 days of accident occurrence.

2 Any person injured who was hospitalized for a period of more than 24 hours. If different national definition is used, please change the footnote accordingly.

Country: **Indonesia**
Agency Reporting: **Directorate General of Highways, Ministry of Public Works**

	2001	**2002**	**2003**	**2004**	**2005**	**2006**
Fatalities[1] (number)	9,522	8,762	9,856	11,204	16,115	15,762
Seriously injured road users[2]	6,656	6,012	6,142	8,983	35,891	33,282
Slightly injured road users	9,181	8,929	8,694	12,084	51,317	52,310
Population	207,995,000	210,898,000	213,841,000	216,826,000	219,852,000	222,747,000
Registered vehicles	21,201,000	22,985,000	26,706,000	30,769,000	38,156,000	45,081,000
Fatalities/10,000 registered vehicles	4.5	3.8	3.7	3.6	4.2	3.5

	2007	**2008**	**2009**	**2010**	**2011**	**% change: 2010–2001**
Fatalities[1] (number)	16,955	20,188	17,481	31,234	32,657	+228.0
Seriously injured road users[2]	20,181	23,440	20,580	46,851	36,767	+603.9
Slightly injured road users	46,827	66,731	60,297	93,702	108,811	+1,307.8
Population[3]	225,642,000	228,523,000	231,370,000	237,641,326	241,182,182	+14.3
Registered vehicles	57,769,000	65,273,000	69,122,250	73,028,645	84,433,514	+244.5
Fatalities/10,000 registered vehicles	3.0	3.1	2.5	4.3	3.9	–4.4

[1] Fatality within 30 days of the accident.

[2] Any person injured hospitalized for a period of more than 24 hours.

[3] Population census: 2000 and 2010.

Country: Japan
Agency Reporting: Traffic Bureau, National Police Agency
(published by Institute for Traffic Accident Research and Data Analysis)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	% change: 2010–2001
Fatalities[1]	10,060	9,575	8,877	8,492	7,931	7,212	6,639	6,023	5,772	5,745	–42.9%
Seriously injured road users[2]	79,673	78,278	75,086	72,777	68,950	64,122	61,010	56,803	53,690	51,528	–35.3%
Slightly injured road users[3]	1,101,282	1,089,577	1,106,345	1,110,343	1,087,683	1,034,077	973,435	888,701	856,425	844,680	–23.3%
Population	127,000,000	127,000,000	128,000,000	128,000,000	128,000,000	128,000,000	128,000,000	128,000,000	128,000,000	128,000,000	+0.8%
Registered vehicles[4]	76,000,000	76,000,000	77,000,000	77,000,000	78,000,000	78,000,000	78,000,000	78,000,000	78,000,000	79,000,000	+3.9%
Fatalities/10,000 registered vehicles	1.3	1.3	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.7	–123.1%

1 Fatality within 30 days of the accident.
2 Any injured person who was treated for over 30 days (medical certificate).
3 Source: Ministry of Internal Affairs and Communications.
4 Source: Ministry of Land, Infrastructure, Transport and Tourism.

Country: Korea
Agency Reporting: National Police Agency

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010[5]	% change: 2009–2001
Fatalities[1]	8,097	7,222	7,212	6,563	6,376	6,327	6,116	5,870	5,838		–27.9
Seriously injured road users[2]	176,318	154,453	173,730	152,141	147,279	139,187	127,643	124,182	126,378		–28.3
Slightly injured road users[3]	210,221	193,696	202,773	194,846	194,954	201,042	208,263	214,780	235,497		+12.6
Population	47,340,000	47,640,000	47,930,000	48,200,000	48,290,000	48,500,000	48,460,000	48,610,000	48,750,000		+3.0
Registered vehicles[4]	12,910,000	13,950,000	14,590,000	14,930,000	15,400,000	15,900,000	16,430,000	16,790,000	17,330,000		+34.2
Fatalities/10,000 registered vehicles	6.3	5.2	5.0	4.4	4.1	4.0	3.7	3.5	3.4		–85.3

1 Fatality within 30 days of the accident.
2 Any person injured hospitalized for a period of more than 24 hours.
3 Any person injured who was hospitalized for a period of more than 5 days and less than 3 weeks (Police reported cases only).
4 Motorcycles not included. 5 Data not yet available.

Country: **Malaysia**
Agency Reporting: **Malaysian Institute of Road Safety Research (MIROS)**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	% change: 2010–2001
Fatalities[1] (number)	5,849	5,489	6,286	6,228	6,200	6,287	6,282	6,527	6,745	6,872	+15.3
Seriously injured road users[2]	8,680	8,425	9,040	9,218	9,395	9,253	9,273	8,866	8,849	7,781	+1.9
Slightly injured road users[3]	35,944	35,236	37,415	38,645	31,417	19,885	18,444	16,901	15,823	13,616	+57.5
Population	23,790,000	24,520,000	25,050,000	25,600,000	26,130,000	26,640,000	27,170,000	27,730,000	28,310,000	28,910,000	+19.0
Registered vehicles	11,300,000	12,070,000	12,820,000	13,760,000	14,730,000	15,800,000	16,810,000	17,970,000	19,020,000	20,007,000	+68.3
Fatalities/10,000 registered vehicles	5.2	4.5	4.9	4.5	4.2	4.0	3.7	3.6	3.5	3.4	–48.6

1 Fatality within 30 days of the accident.

2 Any person injured hospitalized for a period of more than 24 hours.

Country: **Philippines**
Agency Reporting: **Department of Public Works and Highways**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	% change: 2010–2005
Fatalities[1]	–	–	–	–	1,416	1,494	1,303	1,143	1,231	867	–38.8
Seriously injured road users[2]	–	–	–	–	2,548	2,563	2,294	2,370	2,955	1,640	–35.6
Slightly injured road users	–	–	–	–	5,897	6,212	5,887	5,937	5,232	2,193	–62.8
Population	–	–	–	–	85,261,000	86,972,500	88,574,614	90,320,867	92,098,013	93,906,679	+10.1
Registered vehicles	–	–	–	–	5,059,753	5,331,574	5,530,052	5,891,272	6,220,433	6,634,855	+31.1
Fatalities/10,000 registered vehicles					2.8	2.8	2.4	1.9	2.0	1.3	–53.6

1 Fatality within 30 days of the accident.

2 Any person injured hospitalized for a period of more than 24 hours.

Country: **Singapore**
Agency Reporting: **Public Domain (Source from Traffic Police, Singapore Police Force)**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010[6]	% change: 2009–2001
Fatalities[1]	194	199	212	193	173	190	214	221	183		–17.2%
Seriously injured road users[2]	340	173	143	82	88	104	92	10,760[5]	10,748[5]		–0.11%
Slightly injured road users[3]	8,963	8,902	7,880	8,357	8,138	9,602	10,260	–	–		
Population	4,138,000	4,176,000	4,114,800	4,166,700	4,265,800	4,401,400	4,588,600	4,839,400	4,987,600		+3.06%
Registered vehicles[4]	708,969	705,059	707,865	716,907	742,156	776,571	824,388	874,969	910,546		+4.07%
Fatalities/10,000 registered vehicles	2.7	2.8	3.0	2.7	2.3	2.4	2.6	2.5	2.1		

Notes: Source of accident data: Published accident statistics from Traffic Police, Singapore Police Force.

1 Any person who was killed instantly in the accident or who died within 30 days as a result of the accident.

2 Any person who sustains a fracture, concussion, internal lesions, crushing, severe cuts and lacerations, severe general shock requiring medical treatment and other serious lesions entailing admission to hospital and which causes a person to be in severe bodily pain or unable to follow his ordinary pursuits for a minimum period of 7 days.

3 Source: mid-year estimates from Singapore Department of Statistics. Total population comprises Singapore residents and non-residents.

4 Source: mid-year estimates from Land Transport Authority (LTA). Total population comprises Singapore registered vehicles only.

5 From 2008 onwards, the Traffic Police have classified 'seriously injured' and 'slightly injured' as 'injured'.

6 Data not yet available.

Country: **Taiwan ROC**
Agency Reporting: **Institute of Transportation, Ministry of Transportation and Communications**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	% change: 2010–2001
Fatalities	3,344[1] (NA)[2]	2,861 (NA)	2,718 (3,714)	2,634 (3,948)	2,894 (4,358)	3,140 (4,411)	2,573 (3,756)	2,224 (3,459)	2,092 (3,219)	2047 (NA)	–2.2% (2008-2009 -6.9%)
Seriously injured road users[3]	80,612	109,594	156,303	179,108	203,087	211,176	216,927	227,423	246,994	293764	+18.9%
Slightly injured road users[3]	–	–	–	–	–	–	–	–	–	–	–
Population[4]	22.4	22.5	22.6	22.7	22.8	22.9	23.0	23.0	23.1	23.2	+0.18%
Registered vehicles[5] Registered motorcycles[5]	17,500,000 11,700,000	17,900,000 12,000,000	18,500,000 12,400,000	19,200,000 12,800,000	19,900,000 13,200,000	20,300,000 13,600,000	20,700,000 13,900,000	21,100,000 14,400,000	21,400,000 14,600,000	21,700.000 14,800,000	+1.6% +1.6%
Fatalities[2]/10,000 registered vehicles			2.0	2.1	2.2	2.2	1.8	1.6	1.5		+1.6% +1.6%

1 Fatality within 24 hours of accident occurrence. Source: National Police Agency, Ministry of the Interior.
2 Fatality within 30 days of accident occurrence estimated by Institute of Transportation, Ministry of Transportation and Communications.
3 Any person injured in a road traffic accident including seriously and slightly injured road users. Source: National Police Agency, Ministry of the Interior.
4 Source: Ministry of the Interior.
5 Source: Ministry of Transportation and Communications.

Country: **Thailand**
Agency Reporting: **Department of Highways**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010[3]	% change: 2009–2001
Fatalities[1]	11,922	13,116	14,012	13,766	12,871	12,693	12,492	11,267	11,048		–7.3
Seriously injured road users[2]	12,034	16,806	17,066	18,207	19,128	17,852	15,989	12,883	10,113		–16.0
Slightly injured road users	41,926	52,507	62,626	75,957	75,318	65,438	63,040	58,265	51,883		+23.6
Population	62,310,000	62,800,000	63,080,000	61,970,000	62,420,000	62,830,000	63,040,000	63,530,000	63,530,000		+2.0
Registered vehicles	22,260,000	24,520,000	26,380,000	20,620,000	22,570,000	24,810,000	25,620,000	26,420,000	27,180,000		+22.1
Fatalities/10,000 registered vehicles	5.4	5.3	5.3	6.7	5.7	5.1	4.9	4.3	4.1		–24.1

1 Fatality within 30 days of the accident. 2 Any person injured hospitalized for a period of more than 24 hours. 3 Data not yet available.

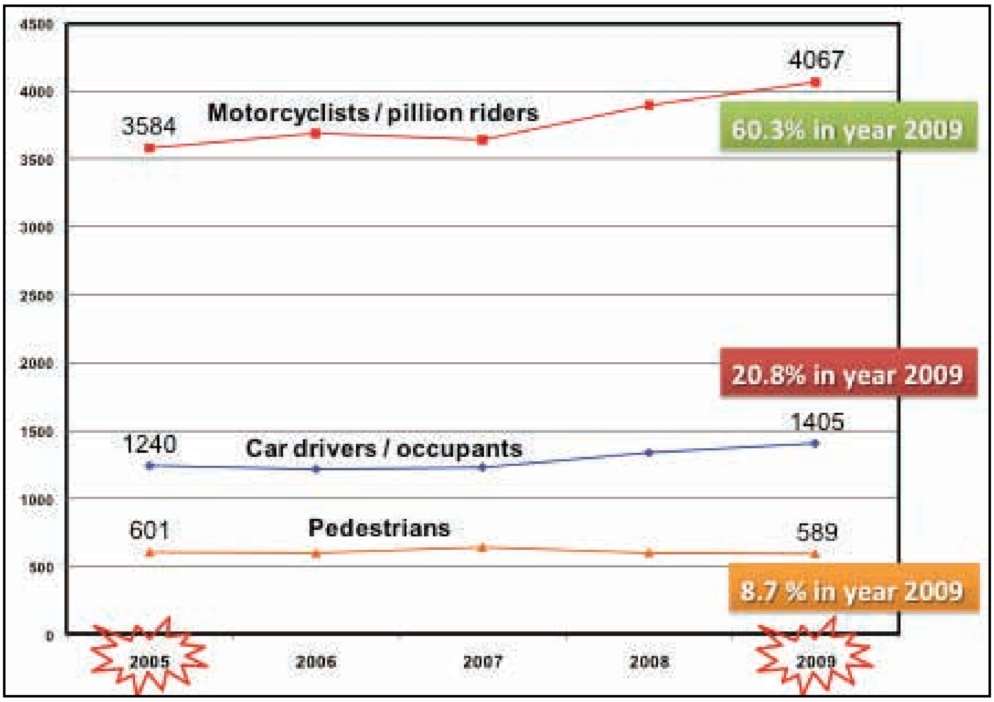
5 CASE STUDIES: MIXED TRAFFIC / SEGREGATION OF MOTORCYCLES

5.1 Mixed Traffic and Segregation of Motorcycles on Jalan Klang-Kuala Lumpur

5.1.1 Introduction

Recent economic growth in Malaysia has led to an increase in the number of vehicles in most cities in the country. The desire to travel quickly from location to location has led many Malaysians who live in urban areas, and who are not drawn from the lower income group, to opt for motorcycles as their means of transportation to avoid traffic congestion. This is believed to have contributed to an increase in motorcycle fatalities in Malaysia. Malaysia is considered as a developing country; the vehicle fleet comprises approximately 47% registered motorcycles compared to most developed countries, where motorcycles make up approximately only 1-5% of the fleet.

An examination of the road fatality data presented in Figure 5.1 shows that motorcyclists were the highest casualties in all road accidents in 2009 (60.3%), followed by cars (20.8%) and pedestrians (8.7%). The number of fatalities involving motorcycles had also increased from almost 3,600 in 2005 to over 4,000 in 2009. This situation was alarming, as Malaysian authorities had taken many measures to try and reduce the road toll. Examples included the *Ops Sikap* campaign (i.e. enhancement of enforcement activities during festive seasons), road safety education through the mass media and enforcement of the road regulations.



(Source: Suret Singh 2010)

Figure 5.1: Comparison of fatalities according to road user type

In terms of motorcycle fatalities, the following issues were identified by Suret Singh (2010) as contributing factors: (1) road user behaviour, (2) vehicle characteristics, (3) mixed traffic system, (4) road characteristics and (5) weather conditions. The study focused on why a mixed traffic system was less favourable for motorcycles and how the segregation of motorcycles from the remainder of the traffic stream could be effective in reducing the number of fatalities involving motorcyclists.

5.1.2 Issues Addressed

Speeds in a mixed traffic system

In a mixed traffic system, motorcyclists share the road with larger vehicles. This results in a differential of cruising speed. Whilst the scenario of vehicles travelling at different speeds may seem harmless, a study of traffic speed conducted by the US Federal Highway Administration (FHWA 1998) clearly showed that vehicles travelling either slower or faster than the median speed were more likely to be involved in an accident. It was also suggested that the chance of an accident increased exponentially the faster the vehicle travelled above the median speed.

The differences in speed in mixed traffic are directly related to the different capacities of vehicles on Malaysian roads. In general, the larger the capacity of the vehicle, the faster it will be able to travel without compromising stability and driver comfort. However, this can also lead to speeding, which can result in accidents, either directly or indirectly. This can be especially dangerous for motorcyclists with nothing more than their clothing and a crash helmet for protection.

Dangerous driving in a mixed traffic system

As well as speeding, other issues are dangerous or aggressive driving. Dangerous driving comes in various forms. For example, large overloaded vehicles having difficulties accelerating and braking are a common sight on Malaysian roads. This is especially true for trucks carrying earth or gravel which can fall from the truck; this poses a potentially fatal threat should the falling debris hit a motorcyclist.

Drivers who are having emotional problems are also often involved in road accidents in Malaysia. Anger is the most common causes of reckless driving in Malaysia. According to Deffenbacher (2003), frustrated drivers may perceive some offence and turn it into ‘road rage’: swearing, yelling and gesturing to drivers and upsetting them and the people travelling with them. This can in turn lead to retaliation in the form of assaults or crashes potentially causing serious injuries or deaths. Changing lanes frequently and rapidly without prior notice, running red lights at intersections, tailgating and braking heavily are common causes of accidents. These pose a dangerous threat to all motorists but are especially threatening to motorcyclists.

Careless driving in a mixed traffic system

Unlike reckless drivers, careless drivers are not aggressive, but rather ‘occupied’ with other activities and not entirely focussing on their driving. The common causes of distractions whilst driving are talking on a cell/mobile phone, trying to send, or reply to, a short-message-service (SMS), eating or drinking, pets, children and operating other electronic devices while driving (e.g. CD players).

All road users drive carelessly on occasions, including motorcyclists. Whilst most motorcyclists would not attempt to operate an electronic device whilst riding, those who do are exposed to a much higher level of danger. These risks are obviously preventable; however, due to road user ignorance or arrogance, many accidents can occur which not only endanger the careless driver/rider but also other road users.

Another cause of distraction to drivers is the tendency to slow down and look (‘gawk’) at other accidents. This can also lead to accidents, especially rear-end collisions.

Poorly-maintained roads

Poorly-maintained roads are also a contributing factor to road accidents in Malaysia. The most common problem is potholes, followed by the ponding of water. However, the number of fatalities that can be directly attributed to a poorly-maintained road is not as significant as the factors discussed above.

In an analysis of accident statistics, Granda (2006), found that 57% of accidents were driver related, followed by a combination of the road and the driver (27%) and a combination of the vehicle and the driver (6%). The remaining 10% were made up of less significant factors. Similarly, research conducted by Suret Singh (2010) indicated that 67% of accidents in Malaysia were driver related, followed road- and environment-related (28%) and, finally, vehicle-related (5%).

5.1.3 Specific Intervention – Traffic Segregation System

In Malaysia, there are two categories of motorcycle lane classified as exclusive for motorcycle use; inclusive motorcycle lanes and exclusive motorcycle lanes. Inclusive motorcycle lanes are additional lanes located next to the road shoulder; they may or may not have designated pavement markings or barriers. They are common on Malaysia highways (Figure 5.2). However, during peak hours, inconsiderate road users also use these lanes as a means of avoiding traffic congestion. The other drawback of inclusive motorcycle lanes is the fact that they are often used as car parks in major town centres.

Figure 5.2: Shared motorcycle lane

A method recently adopted in Malaysia, specifically in the Selangor and Kuala Lumpur region, is an exclusive motorcycle lane (Figure 5.3). This 25 km long motorcycle lane was installed along Federal Highway Route 2, commencing in the 1970s, through a World Bank Project.

Figure 5.3: Exclusive motorcycle lane

5.1.4 Intended Outcome of Intervention

The intended outcome of the intervention was a reduction in motorcycle accidents, fatalities and injuries. Radin, Mackay and Hills (1995) found that the exclusive motorcycle lane significantly reduced motorcycle accident rates and fatalities.

5.1.5 Description

Radin and Law (2005) concluded that the nominal motorcycle lane width for a travel speed of 70 km/h should be at least 3.8 metres instead of 3.5 metres. This was crucial if rear-end or side-swipe accidents were to be avoided.

Seyed and Hussain (2010) suggested that clear delineation and road markings can alert road users to potential dangers and warn them to reduce speed. Seyed and Hussain found that most motorcycle lanes in Malaysia did not have clear road markings or signboards to advise motorcyclists of recommended speeds, approaching bends or crossings. As a result, in many cases users were unaware of the approaching hazards. It was concluded that the implementation of clear road markings and informative signboards at critical accident-prone sites would help reduce accident rates.

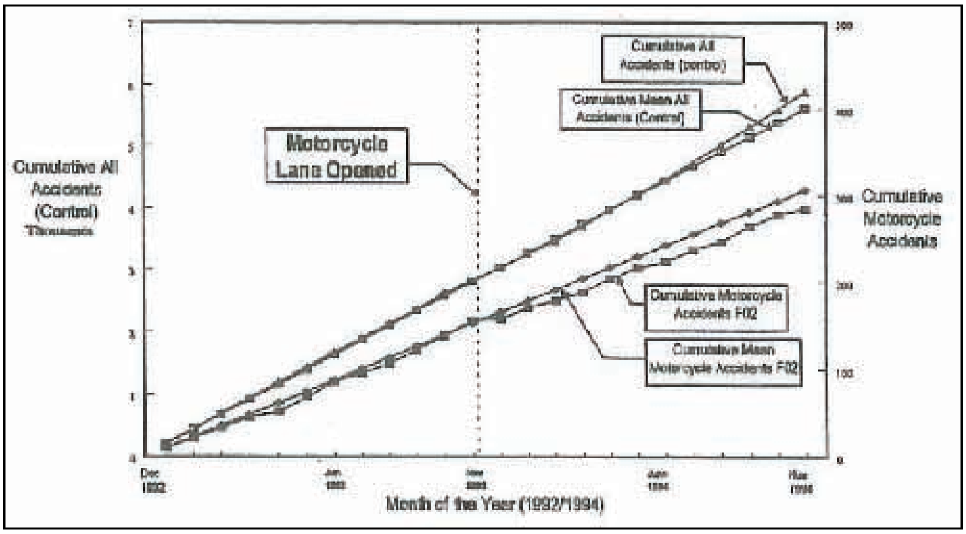
Seyed and Hussain also found that the presence of roadside objects along the exclusive motorcycle lane increased the severity of injuries suffered by the motorcyclist. It was also concluded that barriers such as wire rope barriers were much more dangerous than guardrails and should never be used on motorcycle lanes.

One common complaint from motorcyclists about the exclusive motorcycle lane was that the lane width was too narrow. The width of 2 metres along some sections of the Federal Highway was designed for low-speed, under-powered motorcycles. With larger capacity and bigger motorcycles now becoming widely available, this has led to some dangerous overtaking manoeuvres on motorcycle lanes. At some intersections, there have also been occasions where motorcyclists have to stop and look for passing cars before exiting. This increases the risk of motorcyclists at the front of a queue being hit from the rear.

Radin and Law (2005) reported that, up until that time, there were no specific guidelines or standards for the geometric design and construction of exclusive motorcycle lanes. The only construction guidelines available were *A Guide on the Geometric Design of Roads 8/16* and *A Guide to the Design of Cycle Tracks 10/86*, both published by the Public Works Department Malaysia (1986a and b).

5.1.6 Results

Radin (1996) found that the opening of the exclusive motorcycle lane resulted in a reduction in accidents involving motorcyclist of 39% during in the first 13 months of its operation as shown in Figure 5.4.



(Source: Radin 1996)

Figure 5.4: Trends in motorcycle accidents for the 12 months before and after the installation of the motorcycle lane

Another study by Radin and Barton (1997) concluded that the benefit/cost ratio (BCR) for the motorcycle lane was approximately three, depending on the cost of the accident and the design life of the pavement. This suggests that the provision of exclusive motorcycle lanes can be highly cost-effective in countries where motorcycles make up a significant proportion of the vehicle fleet.

As shown in Table 5.1, the number of recorded fatal accidents involving motorcycles and their pillion riders on the 25 km long stretch of the Federal Highway was seven in 2008, five in 2007 and one in 2006. Radin (1996) found that the provision of the exclusive motorcycle lane resulted in a significant reduction in the motorcyclist accident rate as well as the number of fatalities.

In contrast to this, there was only one fatally involving a motorcyclist on the exclusive motorcycle lane along the Federal Highway between 2006 and 2008. This translates to a reduction of fatal motorcycle accidents of 83%.

Table 5.1: Comparison of Accidents on Federal Highway

Year/Severity	Fatal	Serious	Slight	Damage Only
2008	7	9	17	104
2007	5	8	10	15
2006	1	5	20	55

Accidents that involved motorcycles on Federal Highway (F2)

Year/Severity	Fatal	Serious	Slight	Damage Only
2008	1	1	3	8
2007	1	0	2	2
2006	1	1	3	6

Accidents that involved motorcycles on motorcycle lane along Federal Highway (F2)

(Source: Suret Singh 2010)

5.1.7 Success or Failure

Based on these findings, it was concluded that the provision of an exclusive motorcycle lane resulted in a reduction in fatal motorcycle accidents of 39% by reducing the exposure of motorcyclists to larger and faster vehicles and traffic emerging from blind spots. The risk of serious injury was also reduced significantly.

It is suggested that streamlining and fine-tuning the design of the motorcycle lane could result in a further reduction in accidents. However, the greatest challenge could be acquiring the additional land required for the construction of exclusive motorcycle lanes. The second challenge could be associated with controlling the entry of vehicles into the motorcycle lanes or keeping motorcycles inside it.

The implementation of a traffic segregation system also results in more comfortable and safer travel for motorcyclists, as they do not have to weave in and out of the traffic. The efficiency of motorcycle traffic flow is also increased.

It is concluded that exclusive motorcycle lanes will help to reduce accidents provided they are designed and constructed in line with appropriate standards and specifications.

References

Deffenbacher, JL 2003, *Angry* college *student drivers: characteristics and a test of state-trait theory,* Psicología Conductual, 11, pp. 163-65.

Granda, TM 2006, *Human factors and roadway design: FHWA Perspective* [ONLINE], Available at: http://www.Techtransfer.Berkeley.Edu/Humanfactors/Ihsdm.Pdf [Accessed 28 June 2011].

Public Works Department Malaysia 1986a, *A Guide on Geometric Design of Roads,* Arahan Teknik Jalan 8/86, Kuala Lumpur, Malaysia.

Public Works Department Malaysia year 1986b *A Guide to the Design of Cycle Tracks 10/86,* Arahan Teknik Jalan 8/86, Kuala Lumpur, Malaysia.

Radin Umar, RS 1996, *The value of* exclusive *motorcycle lanes to motorcycle accidents and casualties in Malaysia,* 1, Serdang: Universiti Pertanian Malaysia, pp. 301-2.

Radin Umar, RS & Barton, E 1997, *Preliminary cost-benefit analysis of the exclusive motorcycle lanes in Malaysia*, REAAA Journal no. 9, pp. 2-6.

Radin Umar, RS & Law, TH 2005, D*etermination of comfortable safe width in an exclusive motorcycle lane,* Journal of Eastern Asia Society for Transportation Studies, no. 6, pp. 3372-75.

Radin Umar, RS, Mackay, GM & Hills, BL 1995, *Preliminary analysis of exclusive motorcycle lane along the Federal Highway F02, Shah* Alam*, Malaysia*. Journal of IATSS Research, vol. 19, no. 2, pp. 93-98.

Seyed Farzin Faezi & Hussain Hamid, 2010, *The effect of pavement marking on speed reduction in exclusive motorcycle lane in Malaysia*, Contemporary Engineering Sciences, vol. 10, part 3, pp. 149-55.

Suret Singh 2010, *Road safety scenario in Malaysia* [ONLINE], Available at: http://www.jkjr.gov.my/portal/index.php?option=com_docman&task=doc_download&gid=30&Itemid=225=ms [Accessed 27 June 2011].

United States Department of Transportation Federal Highway Administration 1998, *Synthesis of safety research related to speed and speed management* [ONLINE], Available at: http://www.fhwa.dot.gov/publications/research/safety/98154/ [Accessed 27 June 2011].

5.2 Design of an Exclusive Bus Lane in Taiwan

5.2.1 Introduction

When buses pull into bus stops in the city of Taipei, they often interfere with other vehicles, especially motorcycles. Mixed traffic, which includes buses, not only reduces the efficiency of the traffic flow, but also it can be the cause of many, and severe, accidents (Figure 5.5). The provision of a bus exclusive lane not only increases the operating efficiency of the buses, but also the efficiency and safety of other road users.

5.2.2 Intended Outcome of Bus Exclusive Lanes

It was expected that the use of bus exclusive lanes would reduce the number of conflicts between buses and other vehicles, especially motorcycles.

Figure 5.5: Roosevelt Road has no bus exclusive lanes and buses interfere with other vehicles

5.2.3 Bus Exclusive Lanes in Taipei City

Currently, there are two bus exclusive lane designs used in Taipei: locate the bus exclusive lane on the inside fast lane (Figure 5.6), or locate it on the outside fast lane (Figure 5.7).

Figure 5.6: Bus exclusive lane at Sec. 2, Roosevelt Rd (inside fast lane)

Figure 5.7: Bus exclusive lane at DunHua N. Rd (outside fast lane)

The minimum conditions for the design of an bus exclusive lane are shown in Table 5.2.

Table 5.2: Minimum Conditions for the Design of a Bus Exclusive Lane

	Time of Operation	Conditions
Bus Volume	rush hour	bus flow > 50 vehicles or 2,000 passengers/hour during rush hours
	all day	bus flow > 75 vehicles/hour during rush hours or 500 vehicles in 12 hours
Road Geometry Facilities	rush hour	4 lanes wide on a two-way road or 3 lanes wide on a one-way road
	all day	6 lanes wide on a two-way road or 3 lanes wide on a one-way road

As bus exclusive lanes can affect road users, local residents, and businesses, other factors also need to be considered, including:

- when a reversed bus exclusive lane is designed, it is important to provide appropriate treatments at intersections to ensure safety
- when a bus exclusive lane is designed along the roadside, it is necessary to consider its potential influence on roadside activities such as parking, the movement of motorcycles, hailing taxies, unloading cargo, etc.
- the provision of enough space for bus platforms as well as reflective markings/signs; crosswalks should be designed in order to ensure passenger safety after alighting from the bus
- the strict enforcement of regulations associated with the operation of bus exclusive lanes to ensure they function effectively.

Other issues that need to be considered include the width of the bus exclusive lane, signage, markings, bus priority signals, and the separation of bus exclusive lanes from other lanes.

5.2.4 Results of Evaluation

Accident data relating to the operation of the road before and after three years of operation of the bus exclusive lanes was provided by the Taipei City Police Department. The main findings of the analysis were as follows:

- An analysis of the accidents that occurred on 11 bus exclusive lanes showed that, except for MinQuan W Rd, there were less accidents on many routes since the lanes were installed whilst there was no significant difference in the number of accidents on ZhongHua Rd, RenAi Rd, MinQuan E Rd and ChongQing N. Rd.
- In terms of the severity of the accidents before and after the operation of the bus exclusive lanes, severity only increased on ZhongHua Rd. and ChongQing N. Rd, while the severity on the other routes decreased.
- The number of accidents involving buses decreased after the bus exclusive lanes commenced operation. In addition, the percentage of accidents involving buses also deceased.

5.3 Issues and Solutions to Motorcycle Problems in Indonesia

5.3.1 Introduction

The reality today is that vehicle ownership is growing at a much faster rate than the road infrastructure. The logical consequence of this situation is a decrease in the level of traffic flow quality, which eventually results in a deficiency in the function of the road. As the volume/capacity ratio increases the traffic density in major roads in urban areas and even rural areas increases, as do vehicle operating cost (VOC) and the number of traffic accidents.

One contributor to increasing traffic growth is the increase in the number of motorcycles; the growth in the percentage of motorcycle sales in Indonesia (19%-27%) seems unstoppable. The presences of motorcycles in the traffic stream introduces its own problems, especially in urban areas. Apart from traffic jams, motorcyclists, especially young motorcyclists, are killed as a result of accidents every day.

Motorcycles also contribute to the increase in emissions and a decrease in air quality. In addition, nearly 60% of the government subsidized petroleum is consumed by motorcycles.

These facts suggest that, contrary to popular belief, motorcycles are not an efficient form of transport.

5.3.2 Background

Growth in motorcycle use in Indonesia

The national automotive industry policy that allowed the importation of motorcycles from outside Indonesia prompted several countries to develop and increase their production in cooperation with private enterprise in Indonesia. The policy encourages the acceleration of deregulation in a competitive automotive industry in Indonesia.

The growth in motorcycle sales between 1997 and 2009, and predicted sales to 2015, is shown in Figure 5.8. This data was obtained from the Indonesian Motorcycle Industry Association (AISI). It can be seen that there was an almost 19% growth in sales between 1997 and 2009, whilst the estimated growth between 2009 and 2015 is about 27%. This came after a sharp decline of 72% from 1997 (when 1.853 million units were sold) and 1998 (518,000), this decline being the result of the economic crisis in Indonesia in mid-1998.

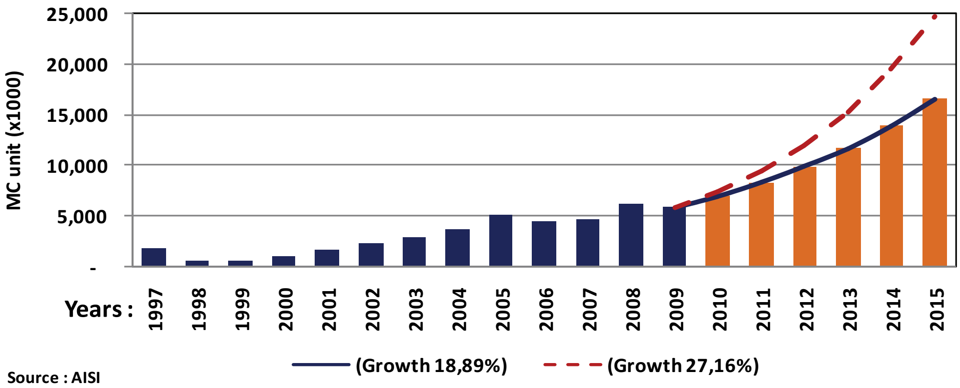


Figure 5.8: Motorcycle sales (1997-2009) and predicted sales to 2015

This has led to an increase in traffic congestion and accidents, particularly in urban areas. The growth in urban traffic of about 9% per year is not being match by the growth in the provision of traffic-related infrastructure, which is typically less than 5% but, in some big cities, less than 1%. The growth in traffic-related infrastructure in Jakarta, for example, is only 0.01% each year.

As shown in Figure 5.9, the motorcycle is now by far the most dominant form of transport. According to data released in September 2010, the number of motorcycles in 2009 was over 87 million, an increase of 235% since 2003, when there were only 19 million motorcycles. This represents over 72% of the total number of motor vehicles in Indonesia. It is almost that about one in three people in Indonesia now own a motorcycle.

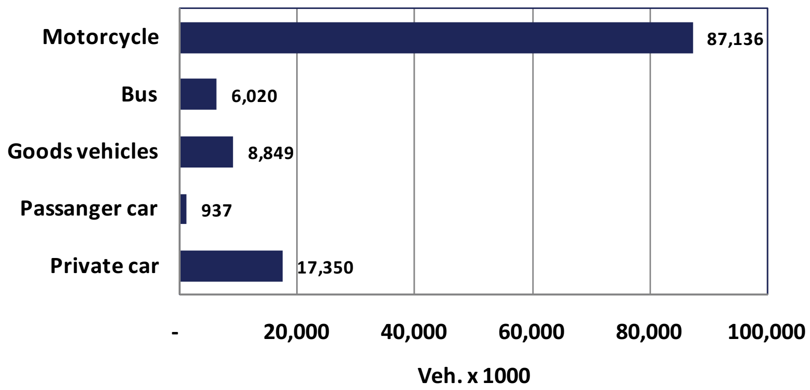


Figure 5.9: Indonesian motor vehicle statistics – 2009

As a result, the traffic at intersections, for example, is well in excess of predicted demands and the intersections are unable to meet these demands in terms of required capacity.

Although there is evidence of change in mode choice from public transport to motorcycles by some road users it seems to be situational, but nothing that can accurately predicted in terms of how long the situation may continue. This is unsatisfactory; there should be a clear policy based on the safe operation of motorcycles as part of the traffic flow. As this transport mode is a potential contribution to vehicle taxes, the interests of motorcyclists must be accommodated. Policies regarding safety standards which include facilities and infrastructure, such as motorcycle lane facilities, and policies that restrict the growth of the motorcycle as a transport mode must also be considered.

Traffic congestion

Theoretically, traffic congestion is related to the traffic volume approaching road capacity. Some parameters used to measure the performance of road infrastructure are the volume/capacity (V/C) ratio and the level of service (LOS). Commonly, the traffic congestion in urban areas, particularly during the peak hour, is defined as LOS-E, where the 'E' denotes that the traffic flow is near capacity. At that stage it is difficult for the driver to select the desired speed of travel and maneuvering in traffic flow is also difficult. The slightest interruption to the flow of traffic will cause congestion. While LOS-F, the flow of traffic is obstructed and congested; the speed is low and the volume is very close to capacity. This leads to long queues and delays.

Almost at all main roads in urban area, particularly during peak periods, oparate at a LOS of E or F level of services. Observations conducted in Bandung showed that almost 60% of the main roads have congestion problems. The average travel speed, particurlarly during peak periods, is less than 15.7 km/h. Koesnandar (2010) reported that there was a significant corellation between the number of motorcycles and road capacity. He illustrated this in terms of the correlation between the proportion of motorcycles and the V/C ratio, i.e. when the proportion of motorcycles was 10-30% of the total traffic the V/C ratio was between 0.1 and 0.35; when the proportion was 36-75% the V/C ratio was between 0.35 and 0.75.

Traffic congestion in big cities dominated by motorcycles is estimated to result in a significant financial loss. For example, the losses in Beijing , in terms of increased congestion, have been estimated at about Rp2.46 trillion annually. Motorcycles were also responsible for two-thirds of all vehicle-related emissions. If this situation is allowed to continue traffic in Bandung will eventually become grid-locked.

Motorcycle accidents

The other impact of the growth in motorcycle use apart from traffic congestion is traffic accidents. According to the Directorate of Traffic Police Headquarters Republic of Indonesia, there were 17,732 fatalities, of which approximately 80% (14,223 accidents) involved motorcycles.

This percentage is one of the highest in Asia. For example, Husein at al. (2005) and Hsu, Farhan, and Nguyen (2003) estimated that 49% of the total traffic accidents in Malaysia involved motorcycles. whilst the proportion in Taiwan and Vietnam was approximately 51% and 71% respectively (Hsu Tien-Pen 2003).

Horswill and Helman (2001) conducted a series of studies in the UK that attempted to assess the relative contributions of rider behaviour and car driver behaviour towards motorcycles and the physical vulnerability of motorcycles to the increased crash and injury rates of motorcycles compared to cars. It was found that motorcyclists tended to drive at higher speeds than drivers of other vehicles. Other influences were the types of manoeuvres used to pass other vehicles and a tendency to drive close to the vehicle in front. This was in line with the work of Elliott et al. (2003), who also identified the riders wearing dark clothing as another factor.

Huang et al. (2004) described the characteristics of traffic accidents involving motorcycles in Victoria, Australia, in 1992. He found that, during typical movements of traffic, 28.3% of the accidents involving motorcycles occurred with the traffic travelling in the same direction, 28% when the traffic was travelling in the opposite direction, 27.5% during overtaking manoeuvres, whilst 16% involved other movements.

Idris (2007) reported that the breakdown of accidents involving motorcycles in Indonesia was:

- accidents involving pedestrians (24%), which were related to the provision of sufficient priority and a lack of anticipation
- rear-end accidents (15%) when moving in tandem with a short headway
- front-side or a side-to-side accidents in tandem with other vehicle movements (e.g. overtaking) (33%)
- front-side accidents (27%), e.g. when conducting a U-turn.

Most of the accidents involving motorcycles were associated with high speed, suggesting that most traffic accidents involving motorcycles are related to human factors. However, road and environment factors can also contribute when there is a lack of suitable motorcycle facilities.

Impact on environment

The decline in air quality, mainly due to the use of fossil fuels in transport and industry, is generally concentrated in large cities. This affects human health, with decreasing lung function and increased respiratory illnesses. The motorized vehicle sector contributes to carbon monoxide (CO) pollution (98.8%), nitrous oxides (NOx) (73.4%), and hydrocarbons (HC) (88.9%).

Data obtained from the daily Kompas (1 September 2010) showed that the amount of realized volume of subsidized fuel in the fiscal year 2010 was 40.5 million kilolitres, or 4 million kilolitres more than 2009. Kompas also reported that, in 2010, subsidized fuel consisted of premium (21.45 million kilolitres), kerosene (3.8 million kilolitres) and diesel (11.25 kilolitres). Monitoring of premium fuel consumption in 2009 showed that nearly 60% was consumed by motorcycles. It was estimated that about 11 million kilolitres of premium fuel was consumed by motorcycles in 2010. These facts indicate that the high fuel consumption of motorcycles should be balanced with their carrying capacity. This data demonstrates the inefficiency of this type of transportation when viewed at the macro level.

5.3.3 Multifaced Transport Intervention Strategy

There are three multi-faced approaches that can be taken to address the motorcycle problem in Indonesia in terms of the transportation system: macro, mezzo and micro. Strategies at the macro level are more related to spatial planning and transport policy. The strategy at the mezzo level (medium level) is more oriented to transport demand management, whilst the strategy at the micro level (or street level) is more oriented to improving the performance of a road segment or intersection.

Strategy at the micro-level

Principally, the strategy at the micro scale is based on traffic theory. Theoretically, the traffic movement is considered to be moving smoothly if the flow is not disrupted. Any disruption will cause traffic movements to become inhomogeneous. Under these conditions, the traffic speed is not optimal which in turn impacts on the overall road performance. In addition to the traffic flow being inhomogeneous, in many cases the presence of a high proportion motorcycles will affect the performance of the road segment. Therefore, to address the problems discussed earlier, the motorcycles and other motor vehicles should be separated. The aim of traffic separation is to ensure homogeneity of traffic movements. This approach is expected to reduce potential traffic conflicts and ensure that traffic speeds are more stable.

Separation of traffic can be achieved through a variety of methods, including the provision of special lane for motorcycles (share or exclusive motorcycle lane) and a special stopping space facilities for motorcycles (exclusive stopping space for motorcycle) at an intersection. The concept is that separating slow-speed traffic from high-speed traffic will lead to a reduction in motorcycle accidents.

<u>Exclusive stopping space for motorcycles – RHKs</u>

The use of an ‘exclusive stopping space for motorcycles’ (or RHKs) at signalized intersections, was developed by the IRE (Idris 2007). It has been proposed as a solution to congestion problems caused by concentrated volumes of motorcycles at unsignalised intersections. RHK is designed in such a way that there are stopping space facilities for motorcycles during the red phase. It consists of a stop line for motorcycles and a stop line for four-wheeled vehicles. Both sets of markings are placed in sequence and separated by a space (see Figure 5.10).

Figure 5.10: RHK at a signalized intersection

The design was developed from the model of Advanced Stop Lines (ASL) used for bicycles, which are placed in front of the queue of other motor vehicles (Wall, Davies and Crabtree 2003). An area known as the ‘reservoir area’ is located between first and second stop lines. This allows the bike to wait in front of other motor vehicles on the intersection.

This approach is more oriented to homogenization of traffic movement by separating motorcycles from motorized vehicles at intersections, particularly while the phase of traffic light is red. The intention of the RHK is to allow the motorcycle to move into the intersection ahead of the other motorized vehicles. This makes it easier for other vehicles to move and reduces the risk of traffic conflicts, particularly those associated with motorcycle manoeuvres.

Trial conducted in 2007 showed that there were improvements in the operation of intersections after the RHK was applied. Conditions at the intersection became more orderly, only a few motorcycles waited in the front on the stop line and there was less weaving action. The throughput of the intersection increased during both the morning and afternoon peak hours by 11.9% and 12.3% respectively. The conflict patterns also changed significantly, and the conflict rate decreased from 133.4 conflicts/1000 passenger car units (pcu) to 24.7 conflicts/1000 pcu during the morning peak hour and from 111.1 conflicts/1000 pcu to 24.1 conflicts/1000 pcu during the afternoon peak hour. The conflict severity also decreased from 1.83 to 1.43 during the morning peak hour and 1.96 to 1.38 during the afternoon peak hour. Overall the trial of the RHKs was regarded as successful.

In terms of the application of RHK, there are some important parameters that need to be applied to determine the need for the RHK, including when:

- the average number of motorcycle accumulating at an intersection exceeds 69.38 during the red phase
- the proportion of motorcycles exceeds 65.87%
- the motorcycle volume on the VJP exceeds 718 pcu/h
- the rate of conflict exceeds 24.96 conflicts/1000 vehicles
- the proportion of motorcycles turning right is 15.4-25% of all vehicles when there is a left approaching lane
- the proportion of motorcycles turning right is 25-34.5% of all vehicles when there are two approaching lanes (left and centre)
- the proportion of motorcycles turning right is greater than 34.47% when there are one or two approaching lanes (middle and right).

<u>Motorcycle lanes</u>

(Idris 2007) reported a study of motorcycle lane usage on urban roads which had motorcycle traffic problems as part of the framework to improve road segment performance through traffic segregation. The studies, which were conducted in Bandung and Yogyakarta, produced some indicators as a reference for determining the need for motorcycle lanes on a road section. The results are summarised in Figure 5.11 and Table 5.3.

Strategy at the mezzo and macros levels

<u>Transport demand management</u>

The strategy at the micro level is essentially involves the implementation of local area traffic management (LATM) which involve low-cost principles of traffic management to improve road segment and intersection capacity. This approach has limited application and may not be effective over a larger sector. The mezzo strategy is based on transport demand management on the urban scale. The most common applications are busways or bus lanes based on railways such as the MRT (Mass Rapid Transportation).

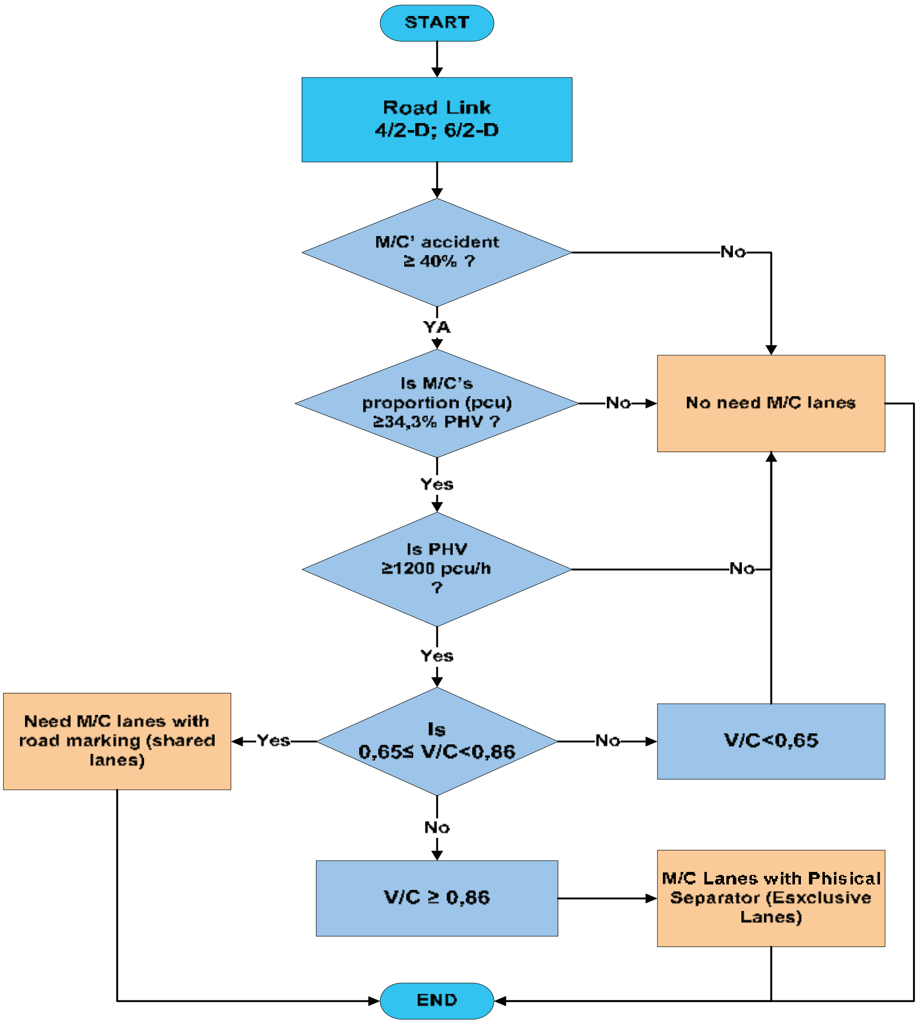


Figure 5.11: Criteria for providing a motorcycle lane
(Source: Idris 2007)

Table 5.3: Performance indicator for motorcycle lane

Performances Indicator	Parameter	Criterion
Safety	M/C accident proportion	$A_{M/C} \geq 40\%$
Traffic flow	M/C proportion	$P_{M/C} \geq 66.5\%$
	M/C proportion in pcu	$P_{M/C} \geq 34.3\%$
	M/C volume (pcu/hour)	Q ≥ 1200 pcu/h
	degree of saturation	Q/C ≥ 0.65

Note: A: accident ; P: proportion; Q: number of flow; C: capacity; M/C: motorcycle

The simplest example of mass transit – which has already been implemented in several cities such as Jakarta (Trans Jakarta), Bandung (Trans Metro Bandung (TMB)) and Yogyakarta – is a busway, which is a bus-based mass transport system. Such a mass transport model needs to be supported by strategic policies and there should be standard minimum levels of service so that the performance can be measured.

At the same time other policies should also be applied, such as limiting the movement of motor vehicles, especially motorcycles, on the routes which the mass transport operates. The purpose of this is to encourage road users to switch to the bus-based mass transportation mode. It is impossible to assess if the program is successfully reducing traffic congestion without policies and compliance to the minimum levels of service. The addition of the TMB Soekarno-Hatta arterial road in Bandung; for example, should have resulted in a reduction in traffic congestion, but no significant benefits have been identified to date.

Another model is the monorail-based transportation system (MRT) applied in Singapore, Thailand and Malaysia. The MRT, which was developed in Bangkok, is an interesting example because, in some respects, the characteristics are relatively similar to the traffic in Jakarta. A more advanced transportation model is the subway as applied in Singapore. Other models include park and ride, carpooling, ride sharing, etc.

Whatever the choice, congestion measures using transport demand management should be integrated with other transport modes, so that the transportation system is capable to providing maximum service to public transport users.

Spatial planning strategies and transport policies

Strategies at the macro level are based on the concept of aligning national and/or regional policies in the development of road and rail infrastructure. The concept must be supported by policies oriented to optimize the utilization of available natural resources, equipment and human resources. Policies related to motorcycles must be driven by restricting the movement of vehicular traffic on the wider region. This approach should be integrated with a spatial planning, road network and transportation system. A good transport system should be sustainable, capable of balancing the technological aspects with the economic, environmental, social and cultural needs and ultimately able to deliver enhanced quality of life to the society.

A different approach that can be taken to reduce the number of motorcycles on the road is to gradually abolish the subsidies provided for this type of transport. Any application of this approach must also be balanced with other transportation programs so that motorcyclists can appreciate the efficiency which was resulted from the implementation of the policy. A good policy is a balanced policy that will provide more flexibility for communities to be able to choose from the existing transportation modes. In this way, motorcyclists are not trapped into a captive group.

Another effective approach may be a policy to limit motorcycle production and also restrict motorcycles being used in certain streets. However, such a policy would be in conflict with the national automotive industry policy where the government requires the development of this industry, especially an increase in national income and employment. In view of this, unless there are other policies, where the orientation of the automotive industry is more directed to the development of mass transportation (such as the rail industry or other buses), a policy limiting motorcycle production would not be favoured. This program certainly has to involve and prioritize the national automotive industry players to work with the world automotive industry.

5.3.4 Discussion

Motorcycle lane facilities

To date there is no policy in Indonesia governing the use of motorcycles including infrastructure provision for them. Although the number of motorcycles is now 2.63 times the number of four-wheeled motor vehicle, they still have to use the existing roads and be exposed to all the risks associated with them. By applying a micro strategy to local traffic problems it may be possible to improve road capacity by optimizing the width of existing roads. However, if such an approach involves the provision of additional land to create a special lane, there are a number of possible consequences but the issue of available funding.

There are at least two major problems related to the provision of special lanes and other transportation policy:

- Can the motorcycle be used for community activities in the same way as four-wheeled motorized vehicles? If so, then the use of motorcycle lanes (shared or exclusive lanes) should be considered.

- Does motorcycle transport is only 'transition' modes, for yet the realization of an adequate mass transit? If so, the provision of special lane for motorcycles by widening the road is deemed unnecessary. However, to support this program, must be seen in the development of public transport needed by the community as a reliable means of transportation that supports the daily activities of society.

If the policy is to provide special lanes for all roads that have motorcycle traffic problems, then such a policy must have a foundation of clear rules. Currently, motorcycles lanes are not catered for in road geometry standards for both urban roads and rural roads. Consequently, rules for the provision of motorcycle lanes must first be standardized, together with the required lane width and traffic arrangements.

Another issue is whether motorcycle lanes should be considered for all classes of road or simply arterial and collector roads. In view of the large growth in the number of motorcycles in Indonesia and the development of mass transport systems, it is suggested that the provision of motorcycle lanes on urban arterial applications could be based on the following guidelines:

- if there is not a high volume of motorcycles; then they can be separated from other motor vehicles by requiring the motorcycles to use only the far left lane
- if the traffic density is high and the volume of motorcycles is also high, the motorcycles can be separated from the other motor vehicles by providing a ‘slow lane’ parallel to the main lane; the lane can be designated using a physical divider or continuous road marking, with motorcycle lanes (inclusive lanes) shared with other slow vehicles
- when the density and volume of motorcycles is high enough, the motorcycles (and slow vehicles) can be separated from the other motor vehicles by improving the road, e.g. by widening the road shoulder, or by raising the standard of the road (e.g. to a highway
- if it is inefficient to share with other motor vehicles, it may be necessary to develop an exclusive motorcycle lane which is an enhancement of the existing road network.

Integrated transport policy

In line with the limited growth and availability of roads, it is reasonable to restrict road users in order to limit road congestion. Two basic policies that can be adopted are: (1) develop the road network, or (2) limited the number of road users. Both policies are quiet difficult to apply. The development of a new road or improving the capacity of an existing road requires a large capital investment. On the other hand, restricting the road users has some impact on the economy. Integrating the two policies is probably the ideal solution. In the future, road management policies need to complement the use of the road according to the types of vehicles, e.g. exclusive motorcycle lanes (LKSM) or excusive stopping space for motorcycles (RHK).

As already discussed, the transport demand management approach is more relevant to future development. In addition to increasing the movement of people and goods, this approach can gradually reduce the need for transportation by using motorcycles. The most important issue is how the modal split will result in efficient and effective transport.

Some policies related to the development of public transport in the medium term should aim to restrict the movements of motorcycles, including the following.

- The provision of bus-based public transport facilities and road infrastructure which has a high level of accessibility to public transport users. It must be capable of providing the maximum service to passengers. The policy must therefore be accompanied with minimum service standards. This policy should also be directed to encouraging motorcyclists to switch to using the provided transportation modes.
- Other policies should be also included, such as providing limited space to motorcyclists, particularly on mass transportation routes.

- Facilities need to be provided so that motorcyclists for change transport modes and continue t to their destination.
- Another policy that could be considered is restricting motorcycles based on their age. This would reduce the number of motorcycle movements in the traffic on urban and rural roads.
- Restricting motorcycle movements would also reduce fuel consumption. Ultimately this approach could lead to greater efficiencies (i.e. vehicle operating costs and travel time) with a broader target to reduce the natural exploitation of premium types of fuel oil.

5.3.5 Conclusions and Recommendations

The imbalance between the growth of road development and motor vehicles ownership, especially motorcycles, has various implications on the operation of the road network. The strategy at the micro level should be to improve efficiency by balancing the lengths of road and the number of vehicles operating on them. In line with this strategy, and in order to maximize the utilization of existing roads, it is necessary to apply traffic management schemes related to the segregation of motorcycles from other motorized vehicles. This can be achieved by providing facilities for the use of motorcycles, e.g. RHK or LKSM.

The provision of LKSM and RHK at signalized intersections would reduce congestion and result in a decrease in the number of accidents. The results of research have shown that traffic conflicts can be reduced by 60-70% and traffic flow increased by 11-12%. Similarly, the application of a special motorcycle lane in Malaysia has led to a reduction in traffic accidents involved motorcycles by up to 90%.

The implementation of strategies at the mezzo level, and associated policies, can result in a more efficient, comfortable and affordable public transportation system. This policy should be accompanied by restricted the movement of motorcycles, especially in road sections that use mass transportation systems. Transportation policies related to the macro level are more oriented to minimizing the scope of movement of motorcycles which can be achieved through the better management of available space.

Another strategy which is also effective but difficult to implement is limiting the production of motorcycles. This policy is strongly associated with the policy of increasing national income. Provided it is more important throughout the policy program then the policy of limiting the production of motorcycles cannot be implemented. Any policy related to motorcycle transportation should not stand alone; it must be integrated with other transportation policies if the most appropriate choice for the road user is to be provided.

References

Elliott, M, Baughan, CJ, Broughton, J, Chinn, B, Grayson, GB, Knowles, J, Smith, LR & Simpson, H 2003, *Motorcycle safety: a scoping study*, Transport Research Laboratory, Laboratory Report LR 581, Crowthorne: TRL.

Horswill, MS & Helman S 2001, *Motorcycle accidents – a summary of EPSRC-funded Project,* EPSRC Fast Stream Grant (number GR/M94724), Department of Psychology, University of Reading.

Hsu, TP, Farhan, MS & Nguyen XD 2003, *A comparison study on motorcycle traffic development in some Asian countries-case study of Taiwan, Malaysia and Vietnam*, Final Report, The Eastern Asia Society for Transportation Studies (EASTS), Taiwan.

Huang, G & Preston, J 2004, *A literature review on motorcycle collisions: final report*, Transport Studies Unit, Oxford University, April.

Husein, H, Radin Umar, RS, Farhan, FMS & Dadang, MM 2005, *key component of a motorcycle-traffic system, a study along the motorcycle path in Malaysia*, Journal IATSS Research vol. 29 no. 1.

Idris, M 2007, *The effect of ESSM (Exclusive Stopping Space for Motorcycles) on traffic conflicts at one signalized intersection in Bandung*, Post Graduate Thesis, School of Architecture, Planning and Policy Development, Institute of Technology Bandung.

Koesnandar, E 2010, *The impact of motorcycles population accident*, Journal Road and Bridges, vol. 27 no. 1, Bandung.

Wall, GT, Davies, DG & Crabtree, M 2003, *Capacity implications of advanced stop lines for cyclists*, TRL Report TRL 585, Transport Research Laboratory, London, UK.

6 CASE STUDIES: VULNERABLE ROAD USERS – PEDESTRIANS AND CYCLISTS

6.1 Measures to Improve Safe-to-Walk Areas in Japan

6.1.1 Outline of Traffic Safety Measures for Safe-To-Walk Areas

In order to implement concentrated traffic safety measures on roads in residential and commercial areas (hereinafter referred to as ‘residential roads’), the National Police Agency and the Ministry of Land, Infrastructure, Transport and Tourism have jointly designated areas with high fatal and injury accident rates, and where there is an urgent need for safety measures to protect pedestrians and cyclists, as ‘safe-to-walk areas’. Phase 1 was introduced in July 2003.

A total of 796 safe-to-walk areas were identified based on accident data collected from 1999 to 2001. They were designated in response to, and in cooperation with, requests from prefectural public safety commissions and road administrators.

A ‘safe to walk’ area has to satisfy the following requirements:

A. total fatal and injury accidents of 42/km^2 or greater[3]

B. trunk roads which, in principle, form the outer periphery of each area

C. an area of about 1-2 km^2.

Specific measures taken vary according to local circumstances. Examples include the following (see Figure 6.1). Examples include the provision of:

- pedestrian and cyclist priority zones by regulating low speed limits or improving road structures spatially; examples include humps and similar structures which decrease the speed of motor vehicles
- pedestrian space networks such as sidewalks
- more advanced and improved signals, etc. and other peripheral trunk road measures at intersections to smooth traffic flow, in order to prevent vehicles from passing through the safe-to-walk area.

6.1.2 Background

About half of all fatal and injury accidents in Japan occur on community roads, including about two-thirds of accidents involving cyclists and pedestrians. Whilst traffic safety measures focused on motor vehicles have successfully led to a decrease in the number of accidents, in terms of pedestrians, the improvement to roads have not been sufficent, and the influx of through traffic into community roads is still a serious problem.

For these reasons, it is essential to promote safety on community roads by improving road conditions, and the road traffic environment, by providing better traffic guidance and regulation, and encouraging safe driving in order to control the speeds of motor vehicles. It is also necessary to introduce traffic safety measures which smooth the traffic flow on trunk roads and prevent motor vehicles, which should be travelling on trunk roads, from entering community roads.

6.1.3 Intended Outcome

The intended outcome of the measures is to lower the fatal and injury accident rate in safe-to-walk areas by about 20% and the rate of fatal and injury accidents involving pedestrians or cyclists by about 30%.

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[3] 1.2 times the average fatal and injury accidents in a DID area.

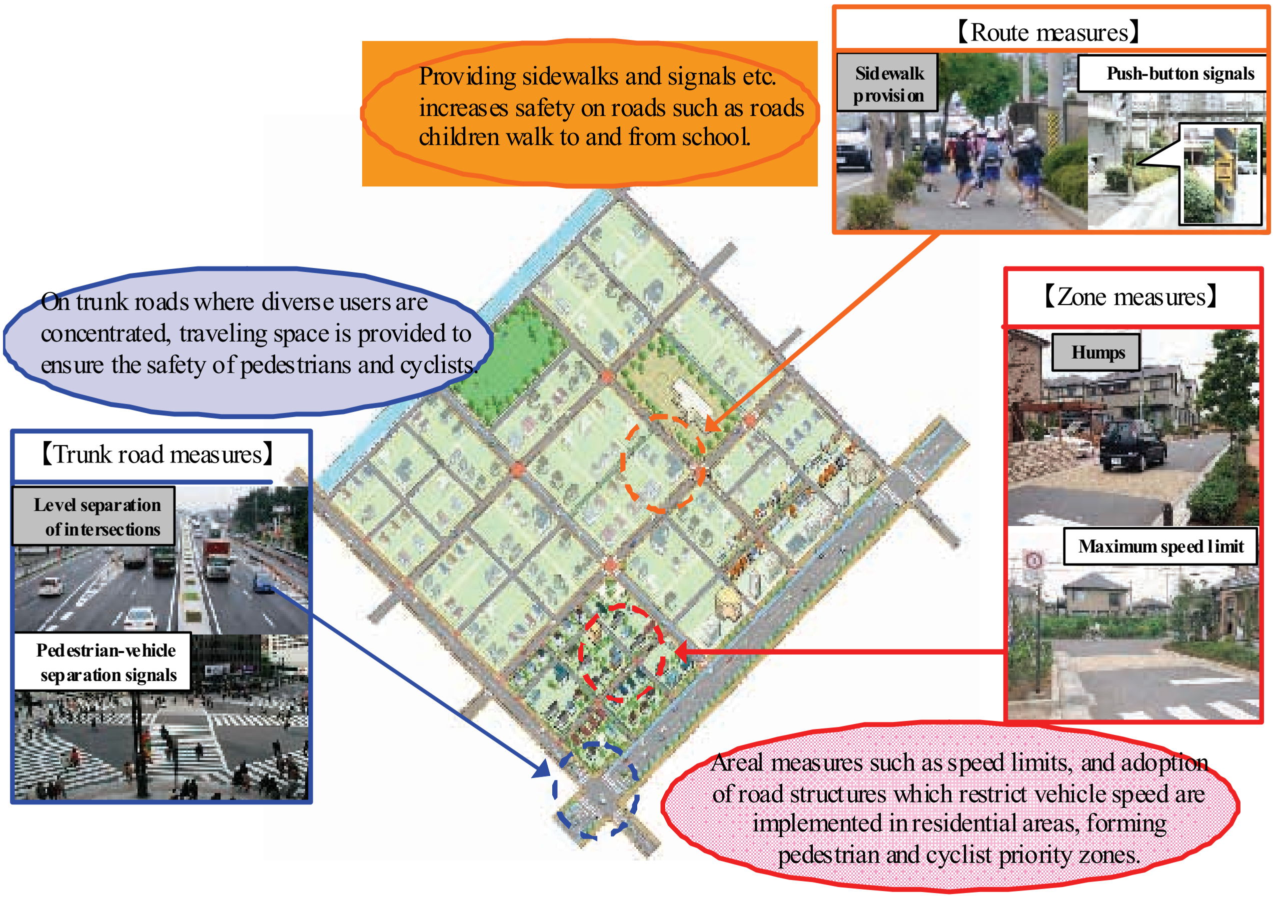


Figure 6.1: Typical safe-to-walk areas

6.1.4 Example of Measures Taken

An example of measures taken is the Higashihatsutomi district of Kamagaya City Chiba Prefecture, about 30 km east from the centre of Tokyo. In this case study, workshops were held and interviews conducted to gather information and reach a consensus regarding the reaction of the residents to the measures carried out.

Some of the measures taken are shown in Figure 6.2. Measures directly linked to traffic safety, such as coloured paving and humps, etc. on intersections have resulted in a reduction in the accident rate by about 62%.

6.1.5 Results of Evaluation

The traffic safety measures implemented in a safe-to-walk area were evaluated from two perspectives:

- Were the measures properly implemented?
- Did taking the measures result in a reduction in the number of fatal and injury accidents?

In terms of the evaluation of the state of the implementation of the measures, the locations were divided into six groups based on the level of achievement during implementation (2003 to 2007) and after implementation (2008 to 2009). The level of implementation was divided into locations where the implementation of the measures had commenced, locations where the implementation was almost complete and locations where the implementation had been completed.

The reduction in fatal and injury accidents was evaluated by examining the difference in the average number of accidents before and after the measures were implemented. The locations chosen were those where the measures had been completed, because it was assumed that the effectiveness of measures would not yet be apparent at locations where the measures were not completed.

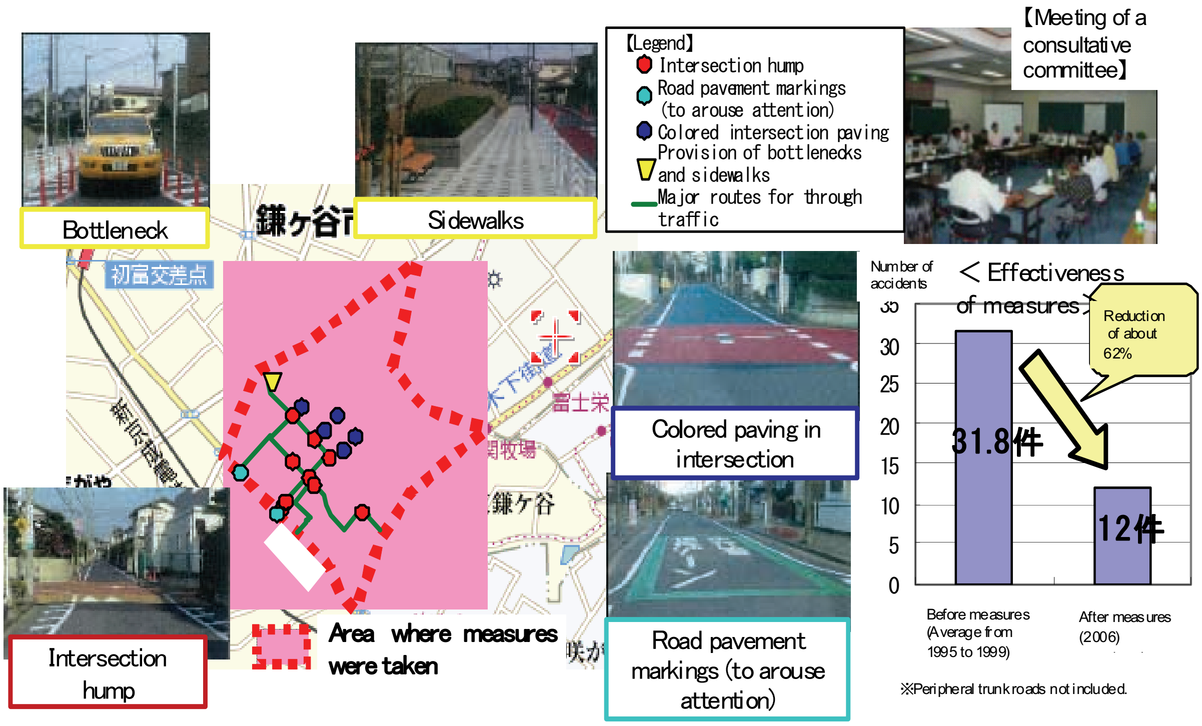


Figure 6.2: Initiatives in Kamagaya City

State of implementation of measures

The status of the implementation of the measures between 2003 and 2007 is shown in Table 6.1. It can be seen that, during the evaluation period, the implementation of measures had commenced in about 99% of the 796 safe-to-walk areas throughout Japan. However, the implementation of the measures had been completed in only about 24% of the locations and completed or nearly completed in a further 61% of the locations.

Table 6.1: Status of implementation of measures during the implementation period (2003-2007)

Locations where implementation commenced	Locations where implementation almost completed	Locations where implementation completed
792 (99%*)	486 (61%)	190 (24%)

Ratio to total number of safe-to-walk areas (796).

The Municipalities responsible for the safe-to-walk areas reported via a questionnaire that the principal reasons for the lack of progress in the implementation of the measures were the following:

- Tight financial constraints restricted the implementation of the measures.
- Involving residents in the project was a challenge because their attitude was passive. There are limits to what local government can achieve when they have to conduct many workshops and similar events necessary to form a consensus. Support must be provided to establish systems to assist in gaining a consensus from residents.
- Administrative bodies lack sufficient technical knowledge of the measures which are most effective in reducing traffic accidents and how the effectiveness of these measures should be promoted to the public.

Reduction in fatal and injury traffic accidents

A total of 190 locations where the implementation of the measures had been completed were evaluated. The evaluation procedure was as follows:

Sum the total number of fatal and injury accidents used to set the targets (annual average from 1999 to 2001).

Calculate the rate of change in the number of fatal and injury accidents nationwide before the measures were carried out (annual average from 1999 to 2001) and after the measures were carried out (annual average from 2004 to 2008). Multiply this number by the first number (a), assuming that the change in the number of accidents was consistent throughout Japan.

Calculate the annual average number of fatal and injury accidents from the year after the completion of the implementation of the measures until 2009.

Compare (b) with (c).

The results, presented in Figure 6.3, show that there was a 17% reduction in the number of fatal and injury accidents at locations where the measures had been completed, which almost met the target of about 20%. However, the rate of reduction in fatal and injury accidents involving pedestrians and cyclists, which was the principal indicator of the effectiveness of the measures, was only about 8%, much lower than the target reduction of about 30%.

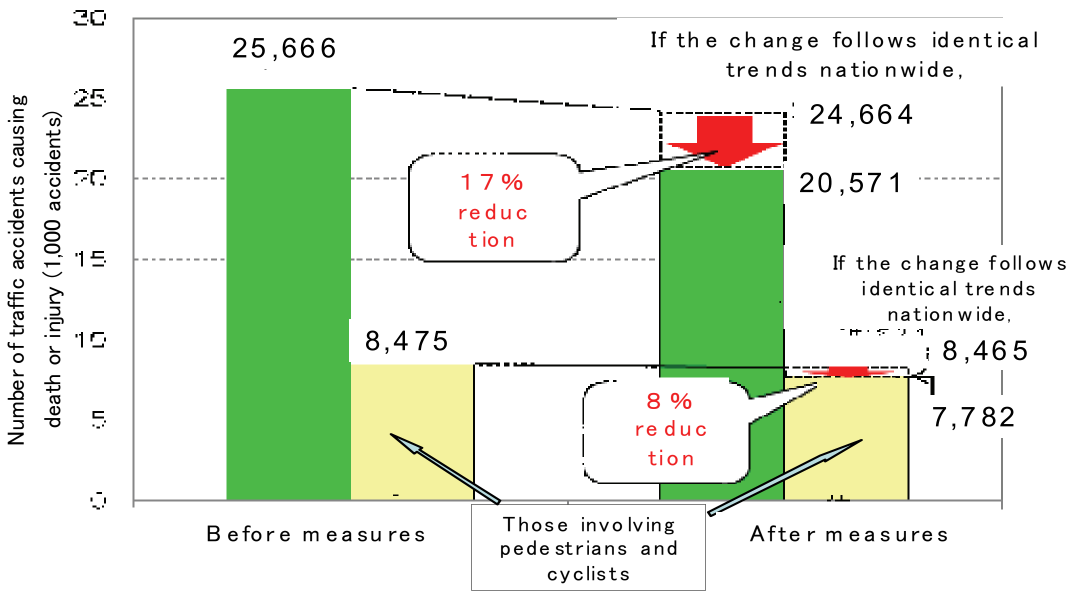


Figure 6.3: Number of fatal and injury traffic accidents and reduction rate in areas where measures were implemented

6.1.6 Future Challenges and Responses

This study of safe-to-walk areas has clearly pointed to the challenges of implementing measures when there is a lack of concensus as to which areas need to be treated and an insufficient budget to adequately implement them. The results revealed that, even at locations where measures were completed, effective accident prevention measures may not have been taken because the reduction in pedestrian- and cyclist-related fatal and injury accidents fell well short of the target.

In order to effectively and efficiently implement traffic safety measures on community roads centered on safe-to-walk areas in the future, it is essential that citizens understand the necessity and potential effectiveness of these measures and reach a consensus through voluntarily participation in workshops, etc. from thecommencement of the planning stage. It is essential that accident prevention measures are developed which are based on sound scientific analysis which addresses the types of accidents that are occurring.

The Japanese government will support initiatives which provide safe and secure pedestrian spaces in all regions of Japan by:

- providing the expertise required to develop schemes which have the full support of the local population
- helping to develop systems which have a sound technical basis
- collecting data and providing technical knowledge such that the effectiveness of measures can be reported and successful examples widely reported to the community.

In 2008, 528 districts were designated as safe-to-walk areas for Phase 2. In response to the challenges discussed in this case study, measures are continually being implemented to achieve the target of cutting accidents involving pedestrians and cyclists by about 20%.

6.2 Enhancement of Safety at Signalised Pedestrian Crossings in Singapore

6.2.1 Introduction

Traditionally, the design of Stop lines and pedestrian crossing (PC) lines in Singapore has been very similar (white continuous lines) except for the different widths (300 mm for Stop lines and 200 mm for PC lines). From the motorists' perspective, the difference between a Stop line and a PC line is difficult to distinguish as the width of the line only differs by 100 mm. In addition, the separation distances of the Stop lines from the PC lines, and between the PC lines, is 3 metres.

It had been observed that, when vehicles stopped for the red light at signalized junctions, they often came to rest beyond the Stop line and encroached into the pedestrian crossings, thus endangering the safety of pedestrians who are sometimes forced to walk outside the designated path in order to keep away from the vehicles (Figure 6.4).

Figure 6.4: Vehicles stopping beyond the stop line

It was hoped that, by using a different design for the PC lines, the number of vehicles not stopping behind the Stop line could be reduced. It was decided, therefore, to change the design of the PC lines from continuous to dashed pedestrian crossing lines (DPCL) to make the distinction between Stop lines and PC lines more obvious (Figure 6.5).

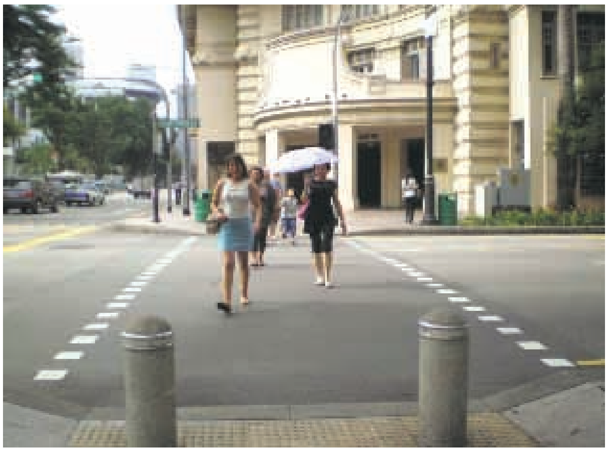


Figure 6.5: Dashed pedestrian crossing lines in Singapore

6.2.2 Literature Review

The use of dashed lines to demarcate pedestrian crossing areas is common in some countries such as Australia (Figure 6.6), whilst a similar concept of dashed markings using steel studs at most signalized crossings has been adopted in the UK (Figure 6.7). Other PC designs such as zebra, ladder and solid markings are also recommended (Figure 6.8); however, they are costly to implement and maintain.

Figure 6.6: Dashed lines in Australia

Figure 6.7: Studs in the United Kingdom

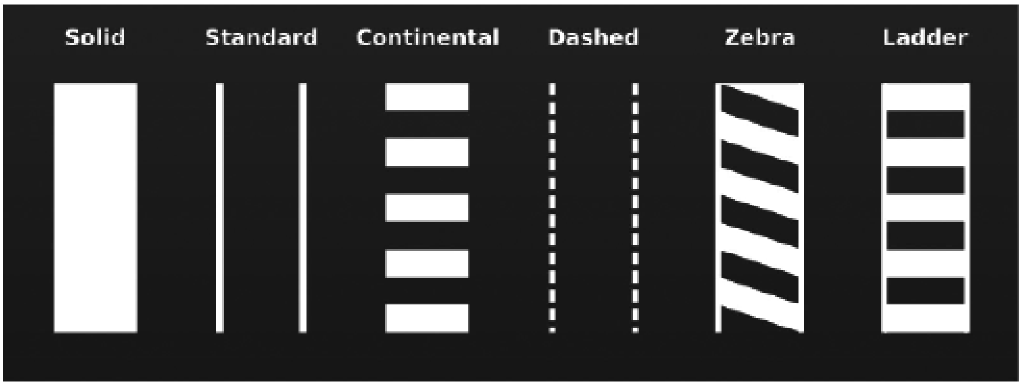


Figure 6.8: Variations in cross-walk pavement markings

6.2.3 Successful Examples

Driver behaviour was monitored during the pilot run to evaluate the effectiveness of the dashed lines. It was found that 77% of the motorists interviewed stated that the dash lines provided a better contrast against the continuous Stop line for vehicles. The proportion of motorists overshooting the stop line also dropped significantly, from 15% to 9% (Figure 6.9).

Figure 6.9: Before-and-after implementation of DPCL

The DPCL was also helpful for the visually-impaired who are able to better detect the broken lines with their walking sticks. This helped to guide them across the pedestrian crossing (Figure 6.10).

Figure 6.10: Crossings with dashed lines are safer for the visually-impaired

6.2.4 Recommendation

It is recommended that the system be implemented at a concentrated area with high usage, such as within a city, followed by implementing nation-wide. For locations where there are concerns of motorists overshooting the Stop line, implementation of DPCL can be brought forward.

6.2.5 Estimated Cost

The cost of implementing the dashed lines at one approach is about 28% less (about S$260) compared to the continuous pedestrian lines (about S$360).

Further Reading

Federal Highway Administration 2011, *University course on bicycle and pedestrian transportation, Lesson 10: Pedestrian facility signing and pavement markings*, available online at http://www.fhwa.dot.gov/publications/research/safety/pedbike/05085/pdf/lesson10lo.pdf, accessed 27 May.

6.3 Improving Sidewalks for the Safety of the Elderly and Physically Disabled in Japan

The *Law for Promoting the Improvement of Public Transportation Accessibility to the Aged and the Physically Handicapped* (the so-called 'the Transport Accessibility Improvement Law') was established in Japan in 2000. Its purpose was to build social infrastructure which allows independent mobility of all people, including elderly and physically disabled people. The *Standard for Road Structure Required for the Smooth Movement of People in the Priority Improvement Area* was established based on this law. Continuing this theme, the *Law for Improving Accessibility for the Elderly and Disabled* was enacted in 2006.

This case study presents the contents of the standards including the width and gradients of sidewalks.

6.3.1 Background

Japanese society is aging at a faster rate than any other country in the world. In 2005, the ratio of people aged 65 and older was 20.2%. It is anticipated that the ratio of elderly people will reach 30.5% of the total population by 2025 and 33.7% by 2035, or about one-third of the population of Japan (Figure 6.11). To prepare for this aging society, it is necessary to provide infrastructure that will permit every member of the population, including elderly and disabled people, to live independently according to their individual will.

It is therefore essential to take steps to permit independent mobility so that people can participate in society. In terms of a walking environment, it is also necessary to implement a variety of measures to improve pedestrian space by widening sidewalks, reducing level differences, making sidewalks flat, etc., so that all pedestrians, including the elderly and physically disabled, can use roads safely.

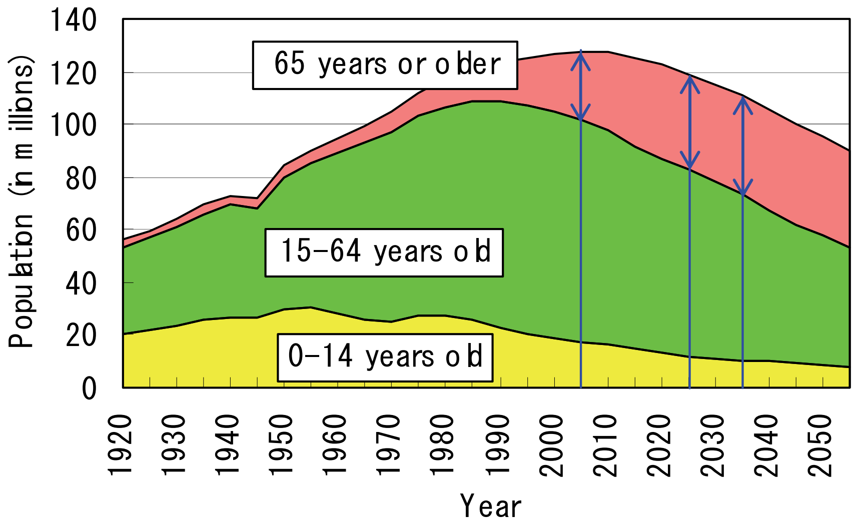


Figure 6.11: Forecast of total population and the elderly population in Japan

6.3.2 Description

The construction of sidewalks in priority improvement areas must comply with The *Standard for Road Structure Required for the Smooth Movement of People in the Priority Improvement Area*. Priority improvement areas are typically located in areas near train stations which service more than 5,000 passengers a day. Municipalities designate these as areas where pedestrian spaces are to be intensively developed for the use of elderly and physically disabled people.

Width of sidewalk

The standard demands that a sidewalk must be separated from the roadway. This is important if elderly and physically disabled people are to move smoothly and safely. The effective width of a sidewalk shall be no less than 2 meters to allow two wheelchair users to meet and pass each other (Figure 6.12).

While the regulations were established in 2000, the standards were altered after the establishment of the *Law for Improving Accessibility for the Elderly and Disabled* in 2006. The main changes included sidewalks had to have an effective width of 1.5 m, while separately installing areas where two wheelchairs could meet and pass each other. Measures to restrict vehicle speed were also implemented rather than installing sidewalks.

Height of sidewalk

In order to ensure the safety of pedestrians, the sidewalk and the roadway are separated by a line of curb stones. The height of the curb stone shall be more than 15 cm and the level of the sidewalk shall be approximately 5 cm higher than that of the roadway (Figure 6.12). The sidewalk pavement shall not be slippery and designed so that it can drain quickly.

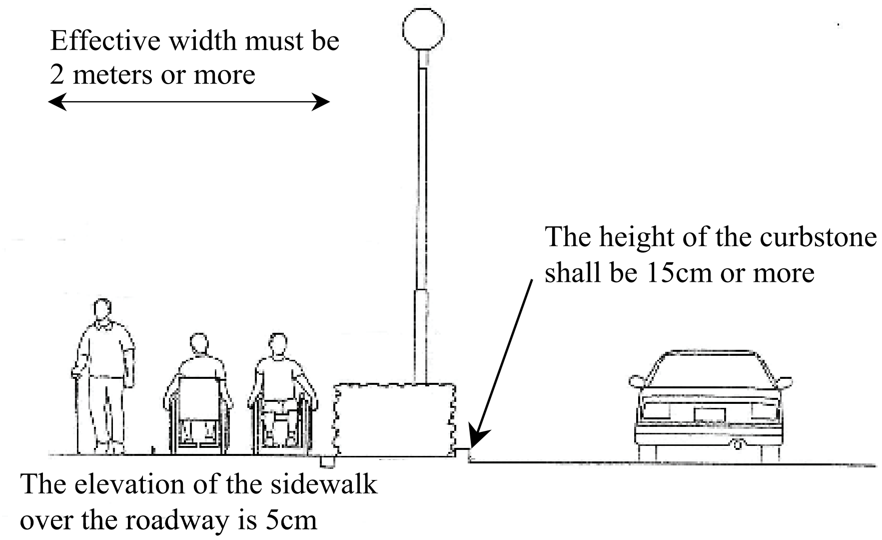


Figure 6.12: Width and height of the sidewalk

Gradient of sidewalk

It is specified that the gradient of the sidewalk shall be as small as possible. The gradient in the walking direction (lengthways gradient) shall not exceed 5% or, if this is not practical, then the gradient can be increased up to 8%. The gradient along the line perpendicular to the walking direction (width gradient) shall be no more than 1% with a drainage pavement. If this is not practical, then this can be increased to up to 2%. Details are shown in Figure 6.13.

Level difference between the sidewalk and roadway

The boundary where a crosswalk joins a sidewalk shall be clearly discernible by providing a level difference of 2 cm, with the sidewalk being higher. This difference of 2 cm is a height discernible by visually impaired persons and is a gap that can be crossed by wheelchair users easily.

Sections of sidewalk which intersect a driveway

In terms of the section of a sidewalk where cars can cross it onto privately-owned land adjacent to the sidewalk, the effective width shall be at least 2 metres. The width of the sidewalk shall be as wide as circumstances allow, and the width gradient shall not exceed 1%. Details are shown in Figure 6.14.

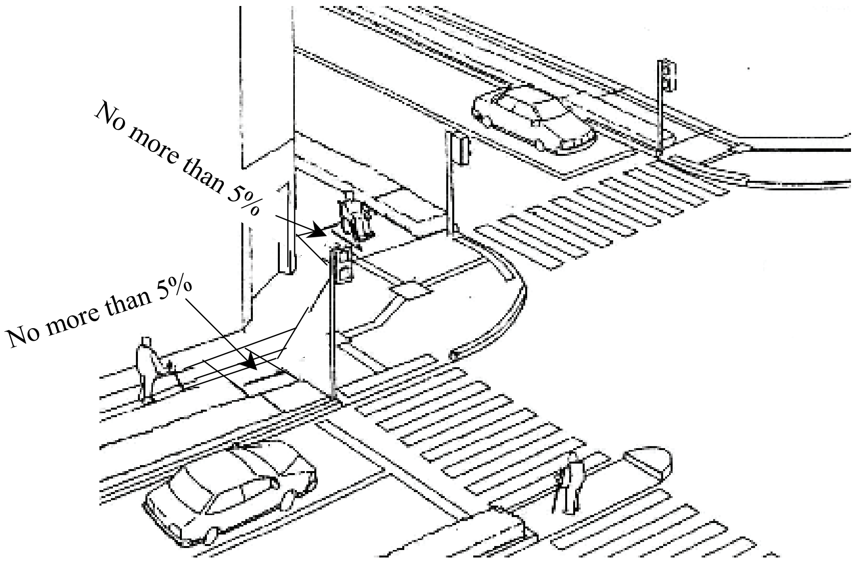


Figure 6.13: Gradient of sidewalk

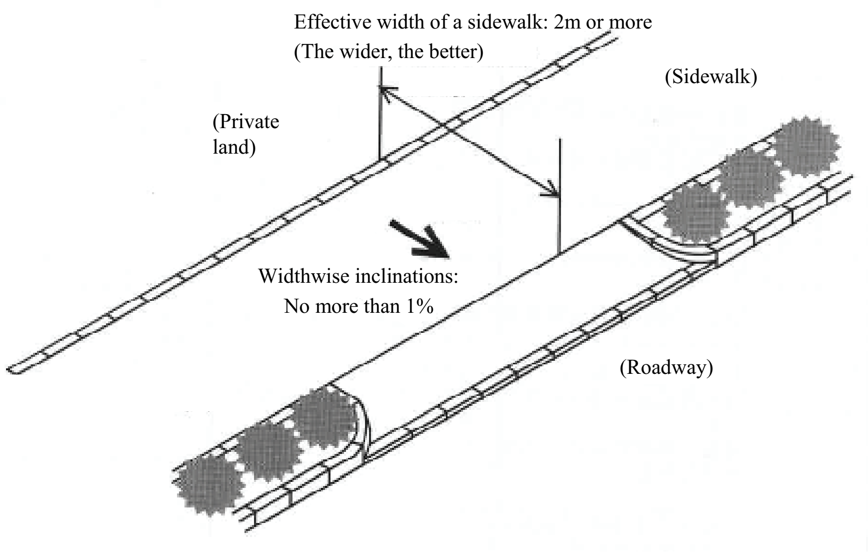


Figure 6.14: Sidewalk intersecting a driveway

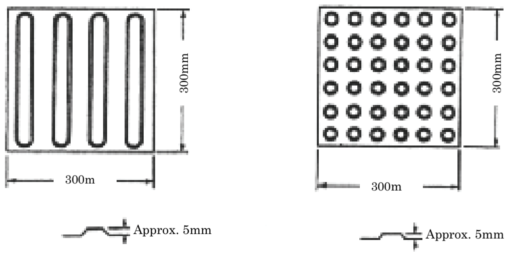
Guiding blocks for visually-impaired people

Guiding blocks for visually-impaired people are installed in order to direct them to the correct walking position and direction on the road. Two types of guiding blocks are available:

1 linear block: a block with parallel linear projections (Figure 6.15a); this is designed mainly to indicate the direction of the facility

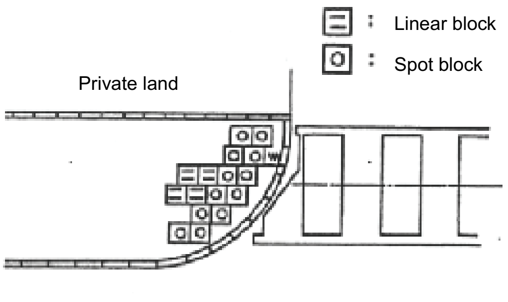
2 spot block: a block with spot projections (Figure 6.15b); this is designed mainly to indicate a location needing particular attention or the position of the facility.

The colour of the guiding blocks shall be yellow or another colour that can be easily distinguished from its surroundings.



(a) Linear Block (b) Spot Block

Guiding Blocks for the Visually Impaired Persons



Setup Example at the Sidewalk-roadway Boundary

Figure 6.15: Guiding blocks for visually-impaired people

6.3.3 Results

As already discussed, pedestrian spaces have been built in the Priority Improvement Areas in Japan based on the standards under the laws. Some examples are shown in Figure 6.16.

The status of pedestrian space development in the Priority Improvement Areas is presented in Table 6.2. The length of roads where pedestrian spaces are to be built is about 1,700 km. About 1,150 km (or about 68% of this length) had been installed by the end of March 2010. More than half of the pedestrian space road length is managed by municipalities. As a result, the future challenge is how pedestrian spaces will be built along municipal roads, including the management of financial issues.

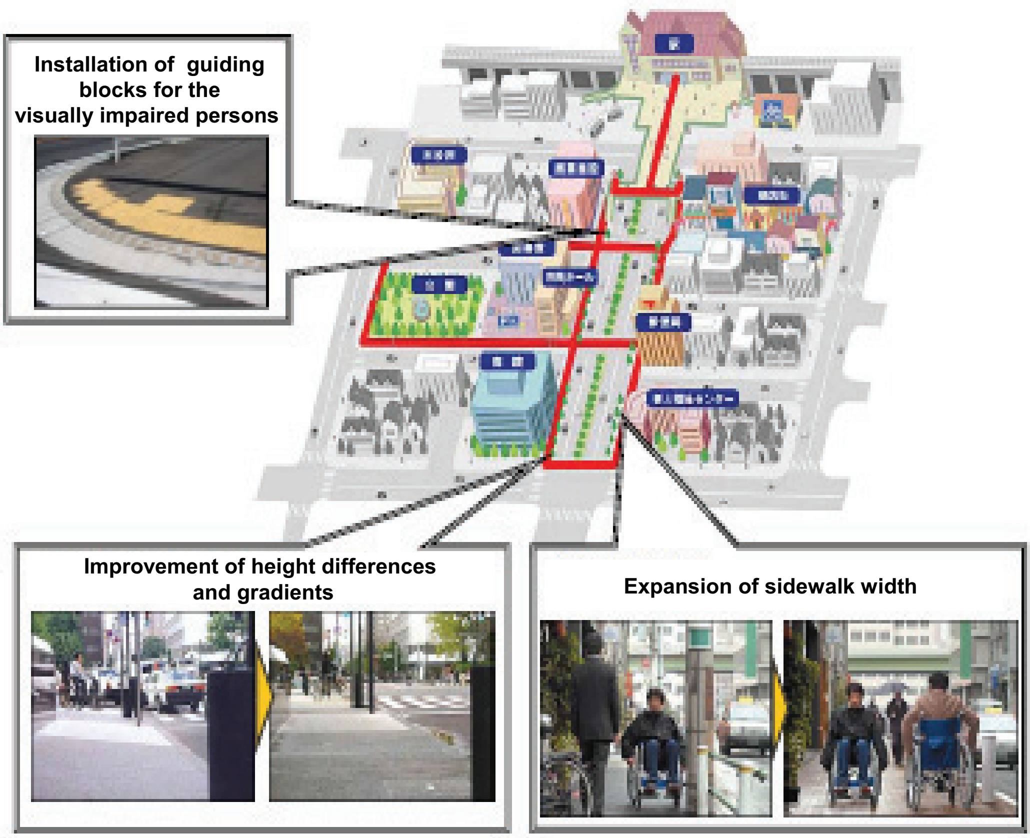


Figure 6.16: Examples of pedestrian spaces in the priority improvement areas

Table 6.2: Status of the Implementation of Pedestrian Spaces (as at March 2010)

	Length of roads where pedestrian spaces are to be built (km)	Length of Roads Where Pedestrian Spaces have been built (km) [ratio]
National Highway (managed by National Government)	190	150 [79%]
National Highway (managed by Local Government)	80	60 [75%]
Prefectural Road	750	340 [71%]
Municipal Road	960	600 [63%]
Total	1,700	1,150 [68%]

Bibliography

National Institute of Population and Social Security Research, 2006, *Population projections for Japan 2001-2050 (medium estimation)* [online], Available at: http://www.ipss.go.jp/pp-newest/j/newest03/newest03.asp.

Regional Road and Environment Division, Road Bureau, Ministry of Land, Infrastructure and Transport 2001, *A guide to networking of barrier-free pedestrian space*, Taisei Press: Japan.

Japan Institute of Construction Engineering 2008, Revised edition of *Accessibility Guideline for Roads*, Taisei Press: Japan.

Planning Division, Road Bureau, Ministry of Land, Infrastructure and Transport 2003, *Accessibility guideline for roads*, Taisei Press: Japan.

6.4 Ensuring Safer Mobility for Cyclists, Pedestrians and Joggers In Residential Areas in Brunei

6.4.1 Introduction

The Brunei Decade of Action for Road Safety (2011-2020) set its *Journey Towards Safer Mobility and Safety on the Road (Pillar 2)*. The aim of Pillar 2 is to address, and place more emphasis on, safer roads and mobility by improving the safety of road networks for the benefit of all road users, especially the most vulnerable: pedestrians, cyclists and motorcyclists. Activities and programs within Pillar 2 (refer Table 6.3) are documented in the *Brunei Darussalam Blueprint on Decade of Action for Road Safety 2011-2020*. They are to be used as a guide to all stakeholders in their strategies to address the issue of safer roads and mobility.

Table 6.3: Activities and Programs: Pillar 2 – Safer Roads and Mobility

1	Enhance the safety of Brunei road networks for the benefit of all road users especially pedestrians, bicyclists and motorcyclists and other vulnerable road users
2	Conduct continuous studies on Brunei roadside infrastructure and speed & other monitoring systems to ensure continuity of the intervention programs
3	Plan and implement road safety inspection (RSI) and road safety audit (RSA) and enhance road assessment programs
4	Introduce technologies onto the Brunei road network to ensure effective communication between the road and all road users
5	Improvise land transportation systems to ensure effective connectivity and safer mobility
6	Encourage relevant authorities to consider all forms of transport and safe infrastructure
7	Address all issues pertaining to safer roads and mobility and continuously strengthen capacity and capability to further enhance effots towards safer road networks

6.4.2 Literature Review

The aim in the next decade is to reduce and minimise deaths and injuries related to road traffic accidents on Brunei's roads. Psychological-technological (psycho-techno) and integrated approaches are being used, based on '5E thrusts': engineering, education, enforcement, environment (road and events due to climate change) and emergency (improving rapid response times to fatal and injury-related accidents and post-crash rehabilitation services).

The RTI accident reduction activities and programs focus on addressing the '5 emphases': speeding, enforcement, driver impairment, road user education and the creation of a safer road environment which is in line with a global focus.

While about 85% of the total vehicle fleet in Brunei is private cars, the percentage of motorcycles and bicycles is increasing. Proactive plans are needed to safeguard these users. It has also been observed that the level of public awareness of the need to maintain their own health has increased as a result of mass promotion carried out in the country. This is considered to be a very positive sign as the leading factors that contribute to deaths in Brunei are health-related diseases such as stroke and heart attack.

Activities such as jogging, cycling and walking are popular among the public in Brunei Darussalam in addition to other sports acitivies carried out within a safe zone or area. The only adverse effect of this positive trend is that most joggers and cyclists tend to carry out their activities in residential areas and along the edge of the road network. The traffic speed along the road network within some residential areas is high and this poses safety and mobility concern that need to be addressed. Over the past few years, fatal and injury accidents in residential areas have been reported. This is of high concern in Brunei and ensuring safer mobility, especially in residential areas, is vital.

6.4.3 Intended Outcome/Objective

The aim of the study is to explore the possibility of enhancing the current roadside environment and infrastructure to provide a safer mobility zone, not only for all motorists but also joggers, cyclists, school children and pedestrians within the vicinity of the Rimba Housing Scheme in the Brunei-Muara District.

6.4.4 Project Description (Transformation Of Housing Area into a 'Safer Mobility Zone')

The layout of the site is shown in Figure 6.17. The implementation of the project involves relevant parties in Brunei such as the Road Department of the Public Works Department and the Brunei National Road Safety Council.

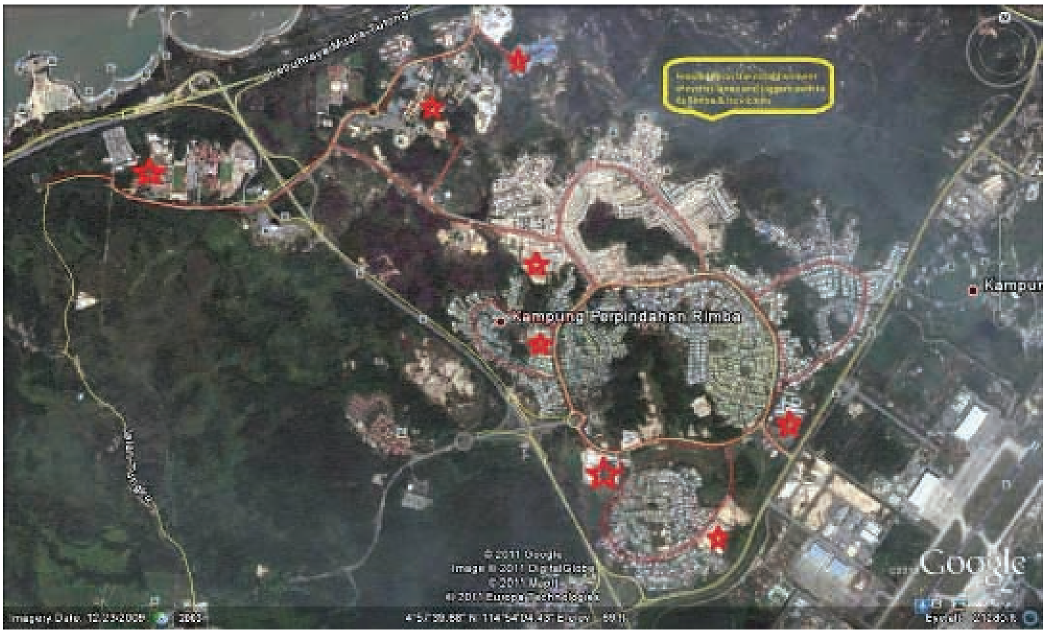


Figure 6.17: Layout of study area

6.4.5 Expected Outcomes and Cost

The Centre for Road Safety Studies will carry out the feasibility study. It is expected to produce recommendations that will potentially lead to project implementation, monitoring and evaluation. As the project implementation will involve several parties, the challenges are how to make the project happen and how it would be funded. The cost of the project implementation will only be known once the study is completed.

The outputs of this project are expected to address:

- road traffic injury-related accidents in residential areas
- safer mobility in neighbourhood areas
- proactive measure to address vulnerable road users, especially pedestrians and cyclists, and motorists who use the residential road network
- enhanced roadside infrastructure and facilities for pedestrians and cyclists
- using the Rimba housing area as a model for the provision of safer mobility zones in other residential areas.

7 OPTIMISATION OF ROAD OPERATIONS: INTERSECTIONS

7.1 Improving Safety for Right-Turning Traffic at Signalized Junctions in Singapore

7.1.1 Introduction

Singapore is an urbanized city which has numerous signalized junctions. The majority of these junctions allow filter right-turns where the vehicles are allowed to turn when the full green signal is illuminated and there is a sufficient gap between through approaching traffic (Figure 7.1).

Such an arrangement improves traffic efficiency at junctions as they reduce the waiting time for right-turning traffic. However, this also means that motorists have to make a judgement as to whether they have a sufficient gap to make the right turn before the next vehicle crosses their path whilst simultaneously looking out for pedestrians crossing at the approach they are turning into. At times, site constraints affect the sight distance needed for motorists to watch out for approaching traffic.

As a result, a fully controlled right turn represented by red, amber and green (RAG) right-turn arrow signals to control right-turning traffic at junctions is implemented in these situations (Figure 7.2). With this arrangement, vehicles are only allowed to turn right when the green arrow, or amber arrow, is illuminated. The red arrow is illuminated at all other times to ban right turns. It serves to reduce the number of decisions drivers have to make and minimizes potential human error, thus reducing the number of 'right turns against through' accidents as well as reducing potential conflicts between right-turning vehicles and pedestrians.

Figure 7.1: Filtered right turn

Figure 7.2: Fully controlled right turn

7.1.2 Literature Review

Corben and Foong (1990) found a 44% reduction in casualty accidents at 30 black-spot junctions in Victoria (Australia) where right-turning phases were installed, with the majority having a fully-controlled right-turn phase. In another study, Bui, Cameron and Foong (1991) compared the impacts of filter right turns (supplemented by a single green right turn arrow) and fully-controlled right turn for Vic Roads, the Victorian state road agency. It was found that the use of fully controlled right-turning phases resulted in a significant reduction in all types of injury accidents. It was concluded that the installation of fully controlled right-turn phases at signalized intersections was a highly-effective way of reducing the incidence of 'right-through' crashes.

7.1.3 Example of Success

Figure 7.3 shows a junction in a residential area that had a high occurrence of accidents, predominantly right-turn-against-through accidents. After RAG was implemented as a treatment, the number of accidents reduced from 22 to six in the 35 months before and after its implementation respectively.

Figure 7.3: Junction in a residential area before and after the installation of RAG

7.1.4 Expected Outcomes and Cost

It is recommended that this treatment be implemented where there is high proportion of right-turn-against-through accidents at a particular approach or when the sight distance of right-turning vehicles is obstructed, e.g. due to flyover columns. The potential disadvantage of this treatment is that the waiting time for the right-turning motorists is likely to be longer. A storage lane may therefore need to be extended to contain the queuing vehicles.

The estimated cost of the treatment is S$4,000-$9,000.

References

Bui, B, Cameron, M. & Foong, CW 1991, *Effect of right turn phases at signalised intersections, part 1 – safety performance*, Report 20, Monash University Accident Research Centre, May.

Corben, B & Foong, C 1990, *Evaluation of accident black spot treatments*, Monash University Accident Research Centre, February (cited in Bui, Cameron & Foong 1991)

7.2 Enhanced Conspicuity at Gore Areas in Singapore through the Provision of a Chevron Zone Red

7.2.1 Introduction

There had been cases reported of vehicles abruptly weaving across the long chevron at gore areas. Gore areas are locations where one or more lanes of the road diverge away from the previous direction of travel. Vehicles weaving abruptly cause safety concerns as this may lead to side-swipe accidents. To minimize the weaving situation, 14 spring loaded poles (SLPs) were installed to serve as a form of physical barrier to motorists (see Figure 7.4). Despite this, however, there were still cases of motorists weaving abruptly across the long chevron and damaging the SLPs. There were three cases of damage to SLPs between June 2005 and August 2007.

Figure 7.4: Long chevron at gore area without red pavement

7.2.2 Literature Review

It is stated in the Singapore *Design Manual for Roads and Bridges* (Department for Transport 1999) that evidence from schemes where coloured surfacings have been used indicated that the colour may enhance other measures implemented to improve safety of operation. For example, coloured surfacings may be used in situations where the main purpose of the colour is to emphasise the message of the prescribed markings to discourage vehicles from encroaching onto an area of the road. Red is the most commonly used colour. The aim is to increase driver awareness and encourage caution by highlighting the area of road excluded (see Figure 7.5).

7.2.3 Project Details

The effectiveness of the red pavement were evaluated based on the savings generated from the costs of repairing the damaged SLPs. Behavioural studies on weaving traffic were also conducted using video recording. Observations were conducted during light (AM peak, AM off-peak and PM off-peak period) and heavy (PM peak) traffic conditions.

7.2.4 Results of Before-and-After Study

Driver behaviour study

The driver behaviour study showed that the weaving behaviour of motorists had not improved after the implementation of the red pavement, i.e. the red pavement at the chevron zone had not influenced behaviour to the extent that road safety was improved at these gore areas.

Figure 7.5: Long chevron at gore area painted red

Damage to SLPs

During the 'after' monitoring period of one year after the installation of the red pavement (April 2008 to March 2009) the SLPs were damaged three times, compared to 1.3 damaged poles per year during the 'before' monitoring period, also of one year. It was concluded that a red pavement may not be effective in reducing the number of times the SLPs are damaged at this location.

7.2.5 Cost Estimate

This is a low cost measure (S$15,500) which involves milling, supplying and laying of the asphalt pavement surface colour and texturing of the chevron zone at the gore area.

7.2.6 Conclusion

The project showed that using the red pavement at the gore area did not lead to a reduction in the weaving problems at gore areas.

Reference

Department for Transport 1999, *Design manual for roads and bridges, volume 6, road geometry section 3, part 4 ta 81/99, coloured surfacing in road layout (excluding traffic calming)*.

7.3 Road Intersection Improvement Plans in Korea

7.3.1 Introduction

In 2008, the number of fatal traffic accident per 10,000 vehicles in Korea was 2.8, which was higher than most developed countries (e.g. USA – 1.7; UK – 1.0; Japan – 0.9; OECD – 1.6 on average). In addition, the social costs associated with traffic congestions in Korea in 2007 accounted for approximately 3% of GDP (or KRW 25.8 trillion). In 2005, the contribution of the traffic sector to the total volume of greenhouse gas emissions was 16.8%. Irrational and unrealistic traffic signals and road operation systems are a major contributor to these statistics.

In response to this, the Presidential Council on National Competitiveness has established schemes aimed at improving traffic signal systems.

7.3.2 Current Status and Issues

Left-turn signals

This signal system causes traffic congestion because the left-turning traffic disrupts the through traffic flow, the volume of which is usually higher than that of the left-turning traffic. Since the 'through traffic priority signal system' has not been established yet, the sequence of signals on each intersection is complicated.

Current traffic signal operation

In developed countries (EU, USA, Japan, etc.) where three-colour traffic lights (two-phase) are used, left turns are permitted under a through signal. Korea currently uses four-colour traffic lights (4-phase) and only through and right-turning traffic is permitted under a through signal. Even on an intersection with a low volume of left-turning traffic, protected left-turns are assigned, often for convenience, and this results in longer signal cycles and more traffic congestion. Most drivers are aware of the long waiting times and, as a result, they cross intersections by taking illegal measures such as speeding and signal violation.

7.3.3 Intended Outcome of Intervention

The intended outcome of the intervention was to resolve chronic traffic congestion by making the signal systems more efficient, thus reducing accidents and also reducing fuel consumption and air pollution related to 'stop-and-go' traffic and idling vehicles.

7.3.4 Description of Schemes and After Study

Establishment of a through traffic priority signal system

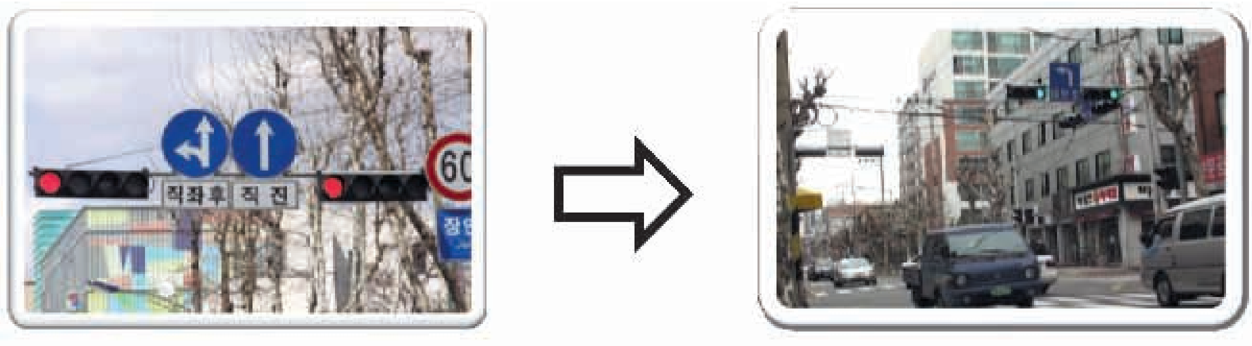
The 'through traffic priority signal system' signal was to be installed at all intersections by 2011. A 'left-turn before through traffic' signal and a 'simultaneous through and left-turn signal' will be changed to a 'through before left-turn' signal. Signs that confuse drivers will also be reorganized.

Improvement of traffic flow by improving the left-turn signal system

This involved a step-by-step expansion of the current permitted left-turns by the installation of left-turn pockets and the operation of all-red signals. It also involved the moving the locations of crosswalks further back from intersections, a lower speed limit in downtown areas (from 60~70 km/h to 50 km/h) and the installation of warning signs.

This was to be accompanied by the rational amendment of related acts and laws stipulating that permitted left-turning vehicles are heavily liable for traffic accidents on intersections. Counter-measures were also established for complementing left-turn signals, including traffic-responsive signal control and the utilization of U-turns and P-turns for reducing the signal cycle.

An example of a complicated signal system and the permitted left turn is shown in Figure 7.6.



Complicated Signal System **Permitted Left-Turn**

Figure 7.6: Example of a complicated signal system and a permitted left turn

7.3.5 Results

Analysis conducted by the Seoul Development Institute (2009) concluded that:

- the average speed at intersections increased by 13 km/h and the average waiting time was reduced by 48 seconds
- the expected cost savings were 5 trillion Korean Won (KRW) per year, including:
  - o reduction in average waiting time: about KRW 2.9 trillion
  - o reduction in fuel consumption: about KRW 1.3 trillion
  - o reduction in CO_2 emissions: about KRW 0.28 trillion
  - o reduction in traffic accidents: about KRW 0.48 trillion.

In terms of actual effects determined in December 2009:

- the travel speed in Seoul and six other metropolitan areas increased by 3.5% and congestion time decreased by 11.3%
- in the five months from July to November 2009, the number of traffic accidents decreased by 690 (14.5%), the number of fatalities by 15 (30.6%), and the number of injuries by 697 (13.5%) compared to the same period in 2008
- the average driving speed in the eight largest cities in Korea increased from 32.5 km/h to 34.4 km/h (or 5.8%).

Reference

Seoul Development Institute 2009, *Quantitative analysis of the effects of advanced traffic operation systems*.

7.4 Effects of Section Speed Enforcement on Expressways in Korea

7.4.1 Introduction

The main cause of traffic accidents on expressways in Korea is speeding. Whilst speed enforcement cameras are widely used in an attempt to reduce accidents, the effectiveness of spot-speed enforcement systems is reduced because car navigation systems identify the location of the cameras and engage in 'kangaroo driving' (see Figure 7.7). In an attempt to reduce traffic accidents more proactively and effectively, section speed enforcement systems have been installed on some sections of expressways. The effects of section speed enforcement systems on expressways were assessed in this study.

7.4.2 Background

Speed control commenced in the Dunnae Tunnel section of the Yeongdong Line for the first time in Korea on 26 December 2007. Details of the system (as at 25 March 2011) are presented in Table 7.1. There has been a high level of public interest in the effectiveness of the system. New systems developed in other countries have successfully resulted in a reduction in accidents, e.g. The Netherlands (▼25%), the UK (▼30%) and Australia.

7.4.3 Intended Outcome of Intervention

The main intended outcomes were that the average section speeds would be lowered and that traffic accidents would be reduced by stabilizing the traffic flow.

Table 7.1: Details of Speed Control in the Dunnae Tunnel

Route Name	Direction	Start (km)	End (km)	Distance (km)	Speed Limit (km/h)
Seohaean Expressway (Seohaedaegyo Bridge)	NB	273.52	282.59	9.03	110
Seohaean Expressway (Seohaedaegyo Bridge)	SB	282.6	273.5	9.12	110
Pyeongtaek·Eumseong Expressway	WB	11.24	5.46	5.7	100
Yeongdong Expressway (Dunnae Tunnel)	EB	168.6	176	7.4	100
Yeongdong Expressway (Dunnae Tunnel)	WB	172.3	161.9	10.4	100
Jungbunaeruk Expressway	SB	223.9	209.8	14.1	110
Jungang Expressway (Jukryeong Tunnel)	SB	242.82	237.2	5.6	100
Jungbu Expressway	SB	85.5	78.0	7.5	100

7.4.4 Description and After Study

Spot speed enforcement system

The objective was to detect and enforce speeding violations at a location. Speed was measured as a vehicle passed over two loop detectors. As already discussed, a limitation was the 'kangaroo' phenomenon of vehicle speed (see Figure 7.7).

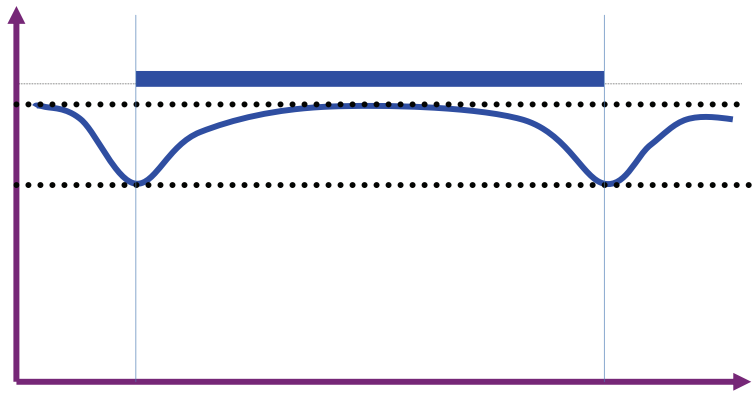


Figure 7.7: ‘Kangaroo’ phenomenon of vehicle speed

Section speeding enforcement system

The objective was to detect, and enforce, speeding violations on a specific section. Vehicle speed was measured using two cameras installed at the start and end points of a section (hundreds of meters to dozens of kilometres in distance) (see Figure 7.8). An advantage was that the ‘kangaroo’ method of driving was prevented.

start point **end point**

Figure 7.8: Cameras set up to record speed of travel

Details of research

The purpose of the study was to examine the effects of the section speeding enforcement system installed on expressways on the traffic flow. The data collected was vehicle speed and the number of traffic accidents. Research was conducted on the characteristics of the traffic flow (e.g. the distribution of average vehicle speed and speed distribution), which may affect traffic safety. Empirical verification of the effects of the system was achieved by comparing and analysing data for both before and after the installation of the system.

7.4.5 Results

The results of the analysis of the traffic flow characteristics on the study sections were as follows:

- the mean speed on the Seohaedaegyo Bridge section decreased by 7.1% (from 97.8 km/h pre-installation to 90.9 km/h post-installation)
- the mean speed on the Dunnae Tunnel section decreased by 4.8% (from 103.7 km/h pre-installation to 98.7 km/h post-installation)
- the mean speed stabilised on both sections
- the number of traffic accidents on the Seohaedaegyo Bridge section decreased by 3.2% (from 0.16 cases/day pre-installation to 0.15 cases/day post-installation)
- the number of traffic accidents on the Dunnae Tunnel section decreased by 12.2% (from 0.67 cases/day pre-installation to 0.59 cases/day post-installation).

The system is expected to improve traffic safety and reduce traffic accidents in the medium to long term.

7.4.6 Future Study

A follow-up study will be conducted which will address the changes in traffic flow characteristics and the reduction in traffic accidents on the sections where the speeding enforcement systems are installed. The analysis will include lane changing, car-following and the observance of designated lanes. In-depth analysis will be conducted of the accident frequency severity and collision types. Schemes for the efficient operation and gradual expansion of the system will also be developed.

7.5 Remodelling of the Gyeongbu Expressway (Osan-Yangjae Section) in Korea

7.5.1 Introduction

The purpose of the study was to establish a scheme for the remodelling of the 37.9 km length of the Gyeongbu Expressway (Osan-Yangjae Section) which was state-of-the-art, consistent and harmonized with the local environment. Road users would also be impressed with the aesthetic nature of the expressway. The remodelling into a Very Important Path (VIP) section would be representative of Korean expressways.

The remodelling of the Osan-Yangjae section involved an analysis of the current status of the roads and facilities, the production of 3-D videos and still images and details of each countermeasure adopted.

7.5.2 Background

The remodelling of the expressway was necessary because there had been many changes in its function and geometric layout due to land use changes in the vicinity. This affected not only the pavement but also the median strips, road marking, bus stops, soundproof walls, guardrails, signs and bridges. The section was also very congested, contributing 12.47% of the total costs of expressway congestion in Korea. User satisfaction, in terms of function and landscape, was low.

7.5.3 Description

The local environment was categorized into dwelling sites, quasi-dwelling sites, green areas and farmland. Improvement proposals were prepared for each category and ‘changes under unification’ pursued. Emphasis was placed on safety and user convenience, with facilities (e.g. bus stops) improved, convenient and pleasant services provided, t dedicated lanes and shoulder lanes utilized and lane width of on-/off-ramps adjusted. The aim was to create a green landscape by increasing the ratio of green space to overall space.

The schemes adopted for the improvement according to each category are shown in Table 7.2, whilst typical photographs showing the section before and after improvement are shown in Figure 7.9.

7.5.4 Results and Summary

The Osan-Yangjae section of the Gyeongbu Expressway has symbolic meaning as it was the first expressway ever constructed in Korea, and it plays a pivotal role in terms of functions. As already discussed, its functions and design have greatly changed due to land use changes in the vicinity of the road.

Recently, the section has become a test field for diverse traffic policies such as bus-only lanes on weekdays, variable shoulder lanes, and a Hi-Pass toll collection system. The driving environment is getting worse due to the adjustment of the road sections.

The purpose of this study was to convert the Osan-Yangjae section of the expressway into a VIP section by creating hi-end public spaces and facilities and addressing the diversified demands of the users and recent policy changes.

Table 7.2: Details of Improvement Schemes

Category	Dwelling Site	Quasi-Dwelling Site	Green	Agricultural Land
Pavement	• low-noise (Q-pave) pavement	• 10 mm PSMA pavement (reforming asphalt) • low-noise (Q-pave) pavement	• 10 mm PSMA pavement (reforming asphalt)	• 10 mm PSMA pavement (reforming asphalt)
Median strip	• Concrete (improved type: 1.27 m)	• Concrete (improved type: 1.27 m)	• Concrete (improved type: 1.27 m)	• Concrete (improved type: 1.27 m)
Bus stop	• a passage into the overpass of an adjacent road			
Soundproof wall	• appropriate brightness and saturation • same materials and design for unification on the same section	• colours with low saturation and medium/high brightness: complicated patterns not used	• see-through type for good landscape	• patterns and design appropriate for the ambient environment
Crash barrier	• crash barrier against high speed	• crash barrier against high speed	• open-type guardrail	• open-type guardrail
Environmental facility and landscape plant	• placed on the front and back of a soundproof wall to create a landscape of tree planting	• placed on the front and back of a soundproof wall to create a landscape of tree planting	• green slopes with plants or flowers	• shrubs planted on the back of guardrails to cover unpleasant facilities
Crossing bridges	• simplified design • planting in spaces below bridges	• simplified design • planting in spaces below bridges	• colours harmonized with ambient environment	• colours harmonized with ambient environment

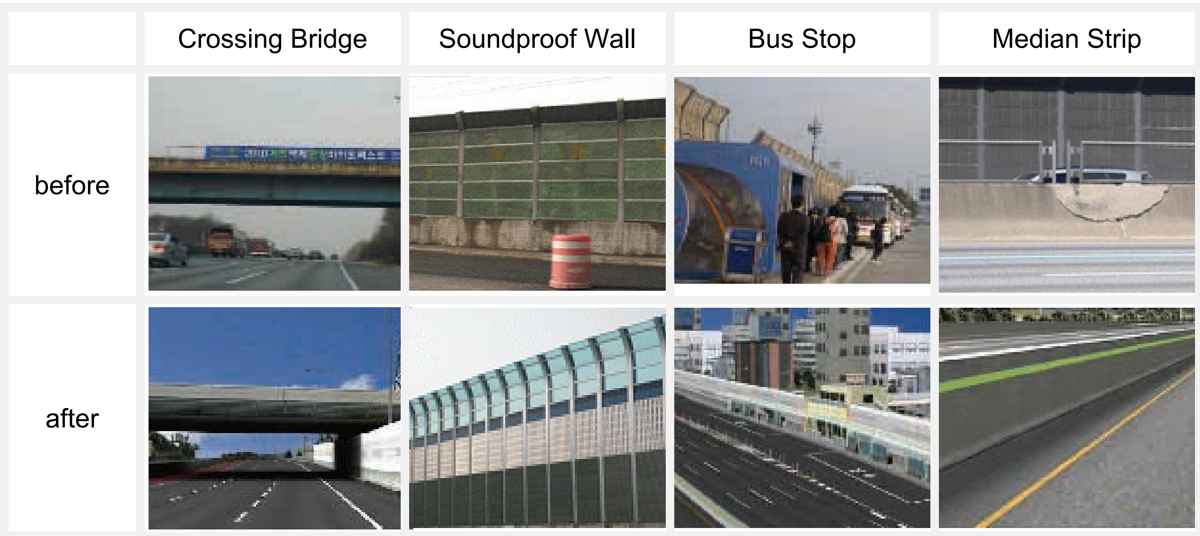


Figure 7.9: Photos of Osan-Yangjae section of Gyeongbu Expressway (before & after)

7.6 T-Junction in Seksyen 26 Jalan Hulu Tinggi 26/6 – Jalan Ijuk 26/5 – Jalan TP 7/9 off Jalan Batu Tiga Lama, Shah Alam Selangor, Malaysia

7.6.1 Issues Addressed

The purpose of this case study was to address the deficiencies of the three-legged junction in Jalan Batu Tiga Lama Shah Alam. Deficiencies observed included the geometrical layout of the junction, road signage and marking and roadside maintenance.

The geometrical design of the junction was affecting the movement of vehicular traffic at the junction. It had become irregular and unconventional for traffic travelling from Jalan TP 7/9 and Jalan Ijuk 26/5, resulting in vehicles taking evasive manoeuvres to avoid collisions. This led to an increase in the number of conflicts at the unsignalised junction. The layout of the junction at Jalan Batu Tiga Lama Shah Alam is shown in Figure 7.10.

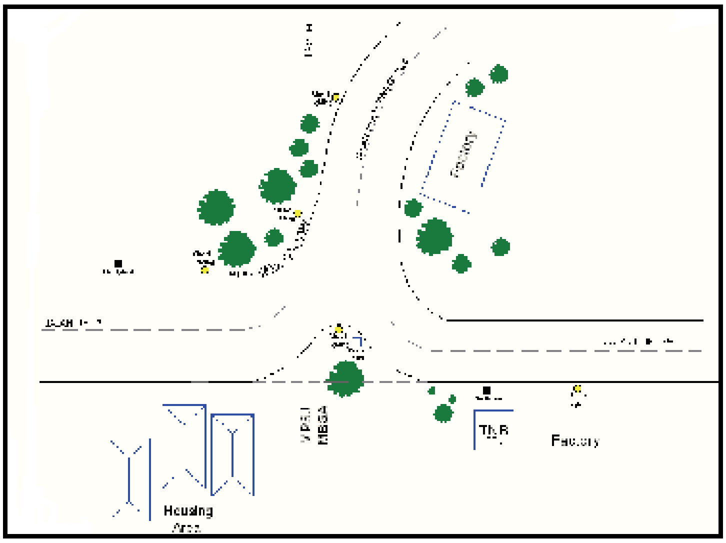


Figure 7.10: Layout of junction at Jalan Batu Tiga Lama Shah Alam

One problem was that there were no advance warning signs to caution drivers of the imminent presence of the encroached area. An unfamiliar road user would probably not notice the presence of the junction which might result in a head-on collision as they would assume that they had right-of-way. Site observations and inspections conducted along Jalan Ijuk 26/5, Jalan TP 7/9 and Jalan Hulu Tinggi 26/6 showed that the centreline road marking was invisible 30 meters from the junction and there was no Stop line mark on any of the three roads to indicate precedence for right-of-way vehicles.

The need for centre line road marking and stop line marking is vital at all times because it guides drivers to stay in the appropriate lanes and allows vehicles that have right-of-way to pass through the junction, thus avoiding the potential for conflict. Driver visibility is reduced during the night and also during wet conditions. This tends to aggravate an already dangerous and risky situation, increasing markedly the potential for vehicle collision. A view of the junction from Jalan Ijuk 26/5 is shown in Figure 7.11.

Another problem was that the feeder pillar and street lighting was positioned in the encroached area and located on the line of direction of traffic travelling from/to Jalan Ijuk 26/5 and Jalan TP 7/9 (Figure 7.12). Vehicles crashing into the pillar could be seriously damaged, the driver seriously injured and damage to the pillar would result in a disruption to the electricity supply to nearby residents. Further, the feeder pillar was located on the line-of-sight of drivers, and this may restrict the sight distance for vehicles approaching the junction from the opposite road.

Figure 7.11: Absence of warning signs – view from Jalan Ijuk 26/5

It was also observed that trees were planted along the roadside at various inappropriate locations such as at the entrance to the junction (Figure 7.13). This reduces the driver's ability to see oncoming vehicles before the driver enters the designated road. Whilst the trees do give shelter to vehicles and pedestrians, and this is much appreciated since it helps to cool down the surrounding area during the day, during the night or when it is cloudy, the trees block the sunlight or street lighting.

Figure 7.12: Location of feeder pillar and street lighting

Figure 7.13: Inappropriate location of trees

7.6.2 Specific Intervention/Regional Intervention

The intended outcome of the interventions was to reduce the number of vehicular conflicts at the junction for vehicles traveling along Jalan TP 7/9 and Jalan Ijuk 26/5 as well as to increase the driver's sight distance from Jalan Hulu Tinggi 26/6.

Several specific interventions have been carried out to increase safety at the junction, including improving the geometrical layout, removing the roadside hazards and improving visual aids. Improving the geometrical layout of the junction included removing the encroached area to facilitate the movement of through traffic so that there were no longer any irregular and unconventional movements. The removal of roadside hazards involved relocating the feeder pillar and street lighting as well as removing the trees which blocked the driver's line of sight. Visual aids were provided in the form of new road markings and the installation of relevant warning signs.

7.6.3 Description and After Study

Changes made at the junction included an improvement in the geometrical layout, the removal of roadside hazards (feeder pillar, street lighting and trees) and the installation of visual aids. 'Before and after' photos are shown in Figure 7.14. The intervention was successfully implemented and produced the intended outcomes. There are no longer any conflicts for the traffic from Jalan TP 7/9 and Jalan Ijuk 26/5.

before

after

Improvement in geometric layout at the junction

before

after

Removal of roadside hazard

before

after

Installation of visual aide

Figure 7.14: Treatments at Jalan TP 7/9 and Jalan Ijuk 26/5 (before and after)

8 OPTIMISATION OF ROAD OPERATIONS: SPEED MANAGEMENT

8.1 Speed Limits in Strip Shopping Centres: Case Study – Victoria, Australia

8.1.1 Introduction

In 2003 VicRoads developed a program involving the setting of 40 km/h speed limits in strip shopping centres to improve road safety. Many of these shopping centres pose a safety problem as they fulfil conflicting roles. On the one hand, they are usually located on arterial roads and are exposed to high traffic volumes; on the other hand, they are sites of significant pedestrian activity.

Strip shopping centres with high numbers of pedestrian crashes were identified for treatment. The types of treatments implemented at these locations involved introducing variable speed limits. In the initial trial, 18 strip shopping centres were treated. An amount of A$3.085M was spent treating 18 strip shopping centres. An example of one the strip shopping centres is shown in Figure 8.1.

Figure 8.1: Typical strip shopping centre in Melbourne

8.1.2 Background/Literature Review

The likelihood of a pedestrian surviving after being hit by a car reduces dramatically above 30 km/h (Figure 8.2) which is consistent with studies such as that conducted by Anderson et al. (1997).

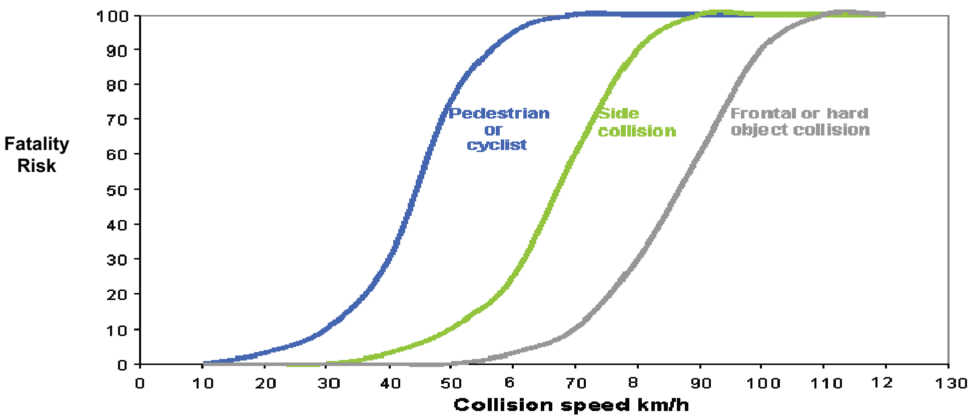


Figure 8.2: Risk of fatal crashes at different collision speeds

8.1.3 Description

The treatment involved the introduction of variable speed limits: the speed limit was reduced to 40 km/h during times of high risk to pedestrians. The speed limit reverted back to 50 or 60 km/h at other times, depending on the prevailing speed limit for that road.

Variable electronic speed signs (see Figure 8.3) were used, along with advance warning signs on the approach to the strip shopping centre. Repeater signs were also used throughout the treatment as shown in Figure 8.4.

Figure 8.3: Electronic variable speed limit sign

8.1.4 Independent Study

An independent study was carried out by the Monash University Accident Research Centre (MUARC) to evaluate the effect of the strip shopping centre treatments on casualty crashes. The study investigated whether the speed limit reduction was a cost-effective road safety treatment; and whether further expansion of the program could be justified.

MUARC undertook a 'before and after' study of the crash history at the treated strip shopping centres. Untreated sections of road with a 60 km/h speed limit in the same local government area were used as 'control' sites. The minimum length of time for a 'before' treatment period was 2.5 years, with the average being 3.6 years, while the minimum length for an 'after' treatment period was also 2.5 years, with the average being 3.2 years.

The use of non-treated 'control' sites meant that the effect of the treatments on casualty crash counts could be isolated from other factors such as improved vehicle design or additional speed enforcement that may have had an impact on the number of crashes at the treated sites.

Analysis indicated that there was an 8.1% reduction in casualty crashes at the treated sites. This was not statistically significant, due mainly to the limited number of sites treated. It was also estimated that the program resulted in an approximate 17% reduction in pedestrian accidents. This result was also not statistically significant.

8.1.5 Costs and Return

If the true effect of the strip shopping centre program was an 8.1% reduction in casualty crashes, then the benefit/cost ratio (BCR) of the program, considering safety alone, would be 7.4. The economic evaluation did not account for the effect of treatments on non-crash-related factors, such as changes in travel times, fuel consumption, local property prices or the profitability of local businesses.

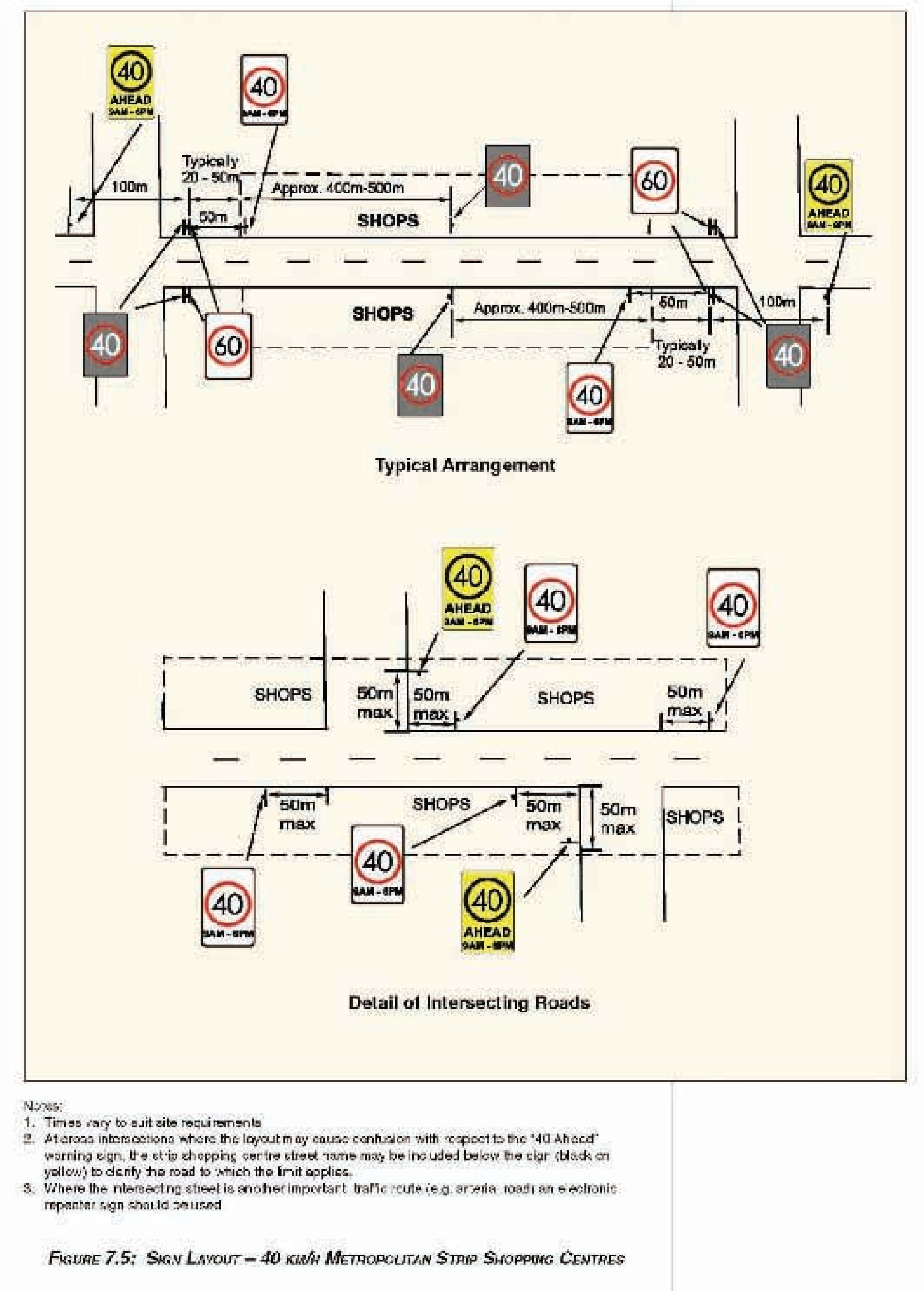


Figure 8.4: Sign layout for strip shopping centre speed zones

A return of a positive economic benefit at the treated sites would have only required a 1% reduction in the number of casualty crashes across all treated sites, each year. This is a reflection of the relatively low cost of implementing each strip shopping centre treatment. Following this evaluation, the strip shopping centre speed zones have been extended, with over 40 treated speed zones now in place.

Reference

Anderson, RWG, McLean, AJ, Farmer, MJB, Lee, BH & Brooks, CG 1997, Vehicle travel speeds and the incidence of fatal pedestrian crashes, *Accident Analysis and Prevention*, 29, pp. 667-74.

8.2 Speed Limit Enforcement: Case Study – Victoria, Australia

8.2.1 Introduction

Speed is a significant factor in a large proportion of fatal and serious injury road crashes. Estimates of the contribution of speed are as high as 30%. As well as having a direct causal role, speed contributes to the severity of most crashes. Compliance with speed is a behavioural issue, with motorists frequently choosing to travel at illegal or inappropriate speeds. Speed enforcement is an important factor in the management of this illegal behaviour.

8.2.2 Background/Literature Review

In developing the *National Road Safety Strategy 2011-2020*, the Australian Transport Council Ministers agreed that action to improve speed management was one of the keys to achieving substantial and rapid road safety gains. The Ministers also agreed that such action should be based on established best practice.

The aim of the *National Road Safety Strategy* is to achieve, by 2020, a substantial improvement in overall compliance with speed limits, particularly on heavily-trafficked and higher-risk sections of the road network.

The broad principles of best practice speed enforcement are as follows:

- speed enforcement should be a component of a broader, integrated strategy to improve road safety outcomes
- there should be a strong focus on improving compliance broadly across the network, in parallel with action to reduce speeds at specific high-risk locations
- enforcement should be supported by well-designed and evaluated communications and public education programs
- both enforcement and communications should address relatively ‘low level’ speeding, as well as extreme speeds.

There is very strong evidence that even small changes in vehicle speeds have a very substantial effect on the total number of road casualties. Fixed and mobile speed cameras have been shown to reduce casualties substantially at the sites where they are used.

The effectiveness of enforcement can also be improved by making enforcement times and locations as unpredictable as possible, and by extensive use of well-publicised enforcement, including overt and covert speed cameras and visible enforcement. In developing a best practice speed enforcement strategy, research and case studies from jurisdictions, both in Australia and internationally, were examined.

8.2.3 Description

Commencing in December 2000, Victoria progressively introduced a package of measures to improve speed compliance, including:

- increasing speed camera operating hours by about 50%
- making the enforcement more covert and unpredictable (see Figure 8.5)
- increasing the number of enforcement sites
- lowering the speed camera enforcement tolerance
- reducing thresholds for penalties that apply to different levels of speeding offence
- increasing advertising about the dangers of speeding.

Figure 8.5: Covert mobile speed camera

Subsequent to the introduction of these measures Victoria has since increased mobile camera hours to approximately 9,000 per month and installed a point-to-point camera system (see Figure 8.6) on the Hume Highway, the major highway between Melbourne and Sydney.

Point-to-point is a technology which allows continuous automated speed enforcement to be applied over an extended length of road. Point-to-point enforcement of heavy vehicle speeds has been in operation in some Australian jurisdictions for some years through Safe T Cam. In Victoria, point-to-point enforcement of light vehicle speeding was introduced in 2007.

Figure 8.6: Point-to-point camera system on the Hume Highway

The first steps in the new *National Road Safety Strategy*, i.e. those actions to be implemented over the first three years to improve compliance with speed limits across the road network, are:

- adopt best practice enforcement, including a combination of on-road policing and speed camera technologies, with a mix of covert and overt strategies
- install, where appropriate, point-to-point cameras to improve speed compliance by all vehicles
- examine options for improved enforcement of motorcycle speeding
- improve the use of sanctions to deter people from speeding more effectively.

Enforcement activity needs to be backed by effective communication programs, aimed at:

- increasing the perceived likelihood that offences will be detected and punished
- increasing the public's understanding of the risks associated with speeding
- influencing perceptions of the social unacceptability of speeding.

To support these objectives, the *National Road Safety Strategy* identified the need to develop a national public information campaign which addresses the community safety benefits of complying with speed limits. This will provide education resources suitable for use by government agencies, local governments and community forums.

Technology solutions to improve speed compliance are also identified in the new *National Road Safety Strategy*. Intelligent speed assist (ISA) systems have been field tested in a number of countries, and many jurisdictions within Australia (see Figure 8.7). These in-vehicle systems are able to automatically detect when a vehicle is exceeding the speed limit on a particular road, and warn the driver of that vehicle. There is evidence that systems with good user acceptability can provide significant safety benefits. Additionally, there are substantial benefits in speed limiting systems for fleet operations, and mandatory ISA systems for high-risk groups, such as repeat speeding offenders.

Figure 8.7: Intelligent speed assist display

Actions identified in the new strategy to facilitate the implementation of ISA are:

- encourage the development of digital speed limit maps
- examine the scope to require advisory ISA in all government fleets and mandatory speed limiting ISA and other technologies for recidivist speeders and P-plate drivers
- initiate discussion with insurers to encourage the voluntary fitting of ISA and recorders through lower insurance premiums, especially for young drivers.

8.2.4 Results and Evidence

A comprehensive statistical evaluation of the impact of the package of measures introduced in Victoria in 2000 to improve speed compliance found that, by the latter half of 2004, there had been a 10% reduction in casualty crashes and a 27% reduction in road deaths (D'Elia, Newstead and Cameron 2007).

An enforcement program will be successful in deterring drivers from speeding depending on drivers' perception of the risk of being caught and their perception of the severity of the penalty or sanctions that would apply, e.g. vehicle impoundment.

The *National Road Safety Strategy* will be reviewed in 2014 and the progress towards the implementation of the initiatives will be assessed. More importantly, this review will measure progress in achieving at least a 30% reduction in deaths and serious injuries.

8.2.5 Costs and Return

The focus of the *National Road Safety Strategy 2011-2020* is to achieve large reductions in serious casualties as a result of enforcement programs aimed at improving speed compliance more broadly across the network, as experienced in Victoria. Additionally, automated enforcement at high-risk sites such as intersections will continue as a cost-effective tool in achieving speed and red light compliance. The result of a side-impact crash at a controlled intersection is shown in Figure 8.8.

Figure 8.8: Side impact crash at controlled intersection

Reference

D'Elia A, Newstead S & Cameron M 2007, Overall impact during 2001-2004 of Victorian speed-related package, report 267, MUARC, Clayton, Victoria.

8.3 Banning the Use of the Count-Down Monitor for the Green Light – Taiwan

8.3.1 Introduction

In Taiwan, 'count-down monitors' are used to show the remaining time of the green light or red light cycle at an intersection as a cue for motorists to prepare to stop or start their vehicles. There are two kinds of count-down monitors. One is the 'plug in' type, which is to located next to the traffic light. Examples are shown in Figure 8.9, Figure 8.10 and Figure 8.11.

The other is the 'built in' type, which is shown in Figure 8.12 and Figure 8.13. The count-down time displays in 1 second intervals. In general, the feedback from drivers is positive.

Figure 8.9: Plug in count-down monitor for green light (yellow number)

Figure 8.10: Plug in count-down monitor for green light (green number)

Figure 8.11: Plug in count-down monitor for red light (red number)

Figure 8.12: Built in count-down monitor for green light (green number)

Figure 8.13: Built in count down monitor for red light (red figure)

The count-down monitor has its advantages and disadvantages. It can relieve a driver's anxiety while waiting at the intersection, improve the efficiency of traffic flow and prevent running of the red light. On the other hand, a driver may ignore other traffic situations and pay full attention to the count-down monitor. Further, when the count-down monitor is operating during the green light cycle, it may cause a driver to speed up as the count-down number approaches 0 to avoid having to stop at the intersection. This can obviously have adverse road safety implications.

8.3.2 Evaluation of Effect of Count-Down Monitor

In order to examine the effects of the count-down monitors, accident data for one year before and after the installation of each monitor was collected and analysed. Accident data at intersections without count-down monitors was also collected in order that the data could be compared and also to reduce the influence of overall traffic variations on the results.

Results of evaluation

The results of the evaluation were as follows.

- The number of accidents and injuries (including fatalities) at intersections with both red and green light count-down monitors was 1.07-1.08 times higher than the number of accidents and injuries (including fatalities) at intersections with no count-down monitors. This suggested that the installation of count-down monitors with both red and green lights did not have the desired effect of improving safety at intersections.
- The number of accidents and injuries (including fatalities) at intersections with count-down monitors with red lights only was 0.42-0.45 times the number of accidents and injuries at intersections with no count-down monitors. This suggested that providing count-down monitors with red lights could reduce accidents.
- The number of accidents and injuries (including fatalities) at intersections with count-down monitors with green lights only was 1.18-1.80 times the number of accidents and injuries at intersections with no count-down monitors. This suggested that providing count-down monitors with green lights may be associated with an increase in accidents.

8.3.3 Intended Outcome

Installing a count-down monitor for red lights was more effective, in terms of a reduction in the number of accidents, especially at intersections with multi-phase traffic lights. On the other hand, the use of a count-down monitor for green lights should be banned to prevent drivers from speeding when the end of the green cycle is approaching.

As a result of this study, the regulation was revised and the use of count-down monitors with green lights was banned in 2007.

8.4 U-Turn Metering in Kota Kinabalu, Sabah, Malaysia

8.4.1 Introduction

Metering is a form of traffic control that is used to hold traffic briefly at the metered/opposing approach to allow traffic at other controlled approaches to make smooth and safe movements. One application is U-turn metering signals which are located at the opposing through-traffic lane in-advance of the median opening where traffic control at this median functions as a priority U-turn facility (see Figure 8.14). U-turn metering was first introduced in Sabah in 2005 with the provision of a *Back Q* detector at a location one-half of the storage length with the signals installed 30 m away. Throughout the years, second generation systems have been developed, including an additional front presence detector to sense long waiting times activate the meter.

It is a low-cost control device as it is only involves the provision of signal heads for through traffic and detector loops with a controller on the U-turn approach**.**

Figure 8.14: Typical example of U-Turn metering in Sabah

8.4.2 Literature Review

Ramp metering systems have long been acknowledged as an effective tool for controlling traffic congestion. They are widely used on a freeway to regulate the access of ramp traffic to the mainstream. The many benefits associated with the implementation of ramp metering have been reported in the literature, including increased throughput capacity (e.g. Diakaki et al. 1998; Hadj Salem, Blosseville, and Papageorgiou 1991; McLean et al. 1998; Owens and Schofield 1988; Papageorgiou et al. 1997); reduction journey times (e.g. Owens and Schofield 1988; Papageorgiou et al. 1997); and decreases in accident rates by 24–50% (Piotrowicz and Robinson 1995).

However, the control system is not without its flaws. Several adverse impacts have been reported, including increased journey time of the merge traffic at the on-ramp (e.g. Owens & Schofield 1988), increased accident rates and reduced traffic at the on-ramp and increased diversion traffic to alternative urban routes (e.g. McLean et al. 1998; Diakaki et al. 1998).

The first ramp metering system was installed in Chicago in 1963 (Lomax and Fuhs 1993). Ramp metering is now widely employed in North America and Europe to alleviate traffic congestion. Though many types of ramp metering control strategies have evolved over the years, the basic principle and aims remain unchanged.

In a ramp metering system, dedicated traffic signals are installed on ramps to regulate the traffic flow into the mainstream (highways, motorway, freeways or dual carriageways) in order to maximize the capacity and avoid congestion and a breakdown in traffic flow (Wu et al. 2007). A typical example of a ramp metering design for vehicles merging onto a highway is shown in Figure 8.15.

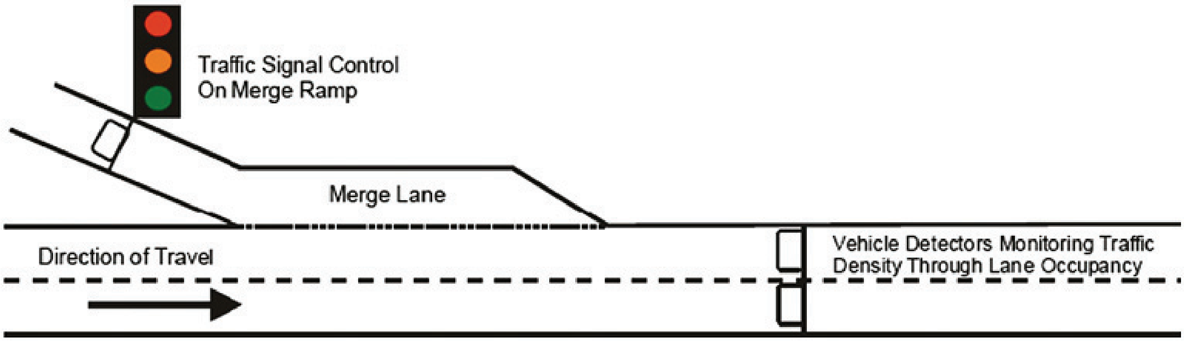


Figure 8.15: Typical ramp metering scheme (Stewart 2003)

8.4.3 Design of U-turn Metering

An example of U-turn metering is shown in Figure 8.16.

Figure 8.16: Design of U-Turn Metering

In this U-turn metering system, detectors are embedded in the pavement along the through-traffic and the U-turn approach lanes. The red light on the through approach is activated when the number of vehicles wanting to conduct a U-turn exceeds the limit. The presence of the front detector is crucial; the necessity for the green signals possible needs to be explored (as shown in Figure 8.17).

Figure 8.17: Green signals at through traffic approach

8.4.4 Advantages and Disadvantages of Metering

The advantages of metering is that it:

- enables U-turns to be conducted safely and comfortably
- ensures that there is no unnecessary/frequent mainline stopping
- helps to avoid queue spillage onto the flow in the through-traffic lane
- allows the U-turn to be conducted at any time provided there is a safe gap in the traffic
- makes traffic priority clearer to all drivers

Overall, it is an effective traffic management/road safety tool. The disadvantages of metering are that some drivers experience anxiety about when to make a turn and that it is a 'back of queue' detection system, i.e. it is not a complete road safety technique.

References

Diakaki, C, Papageorgiou, M & McLean, T 1998, *Integrated traffic-responsive urban control strategy IN-TUC: application and evaluation in Glasgow*, Proceedings of DACCORD.

Hadj Salem, H, Blosseville, JM & Papageorgiou, M 1991, *On-ramp control, local*, In M Papageorgiou (Ed.) Concise encyclopaedia of traffic and transportation systems, pp. 294-300, Oxford: Pergamon Press.

Lomax, TJ & Fuhs, CA 1993, *Geometric design of metered entrance and high-occupancy vehicle bypass ramps*, Transportation Research Record, 1385, pp. 139-47.

McLean, T, Brader, C, Diakaki, C & Papageorgiou, M 1998, *Urban integrated traffic control in Glasgow, Scotland*. In Proceedings of ninth international conference on road transport information and control, London, 21–23 April, IEE Conference Publication No. 454, pp. 243-49, London: IEE.

Owens, D, & Schofield, MJ 1988, *Access control on the M6 motorway: evaluation of Britain's first ramp-metering scheme*, Traffic Engineering and Control, 29(12), pp. 616-23.

Papageorgiou, M (Ed.) 1991, Concise encyclopaedia of traffic and transportation systems, Oxford: Pergamon Press.

Papageorgiou, M & Kotsialos, A 2002, *Freeway ramp metering: an overview*, IEEE Transactions on Intelligent Transportation Systems, 3(4), pp. 271-81.

Papageorgiou, M, Hadj-Salem, H & Middelham, F 1997, *ALINEA local ramp metering: summary of field results*, Transportation Research Record, 1603, pp. 90–98.

Stewart, P 2003, *Ramp metering study, Executive summary*, TPRAMP2/55129, SIAS Limited, Dundee, UK.

Wu, J, McDonald M & Chatterje, K. 2007, *A detailed evaluation of ramp metering impacts on driver behavior*, Transportation Research Part F 10, pp. 61-75.

9 ROAD HIERARCHY

9.1 The Establishment of a Master Plan for an Arterial Road Network in Sumatra

9.1.1 Background

Following the 1997 economic crisis the World Bank estimated that Indonesia's economic growth in 2011 could surpass the 6.4% target and even reach 7% if the Indonesian government carried out a thorough reform in various fields including infrastructure improvements.

Roads play a vital role and have a major impact if the prerequisites are met before the road will be The provision of reliable, safe, convenient, sustainable, effective, efficient and equitable roads plays a vital role in the economic performance of Indonesia in accordance with the mandate of Act No. 38 of 2004. Road administrators have until the year 2014 to improve the accessibility and mobility in the region if economic growth is to be realised and improved social welfare achieved. The provision of an improved road infrastructure as part of the transportation system will provide benefits to the community, economic growth and ease of the mobility of goods and people. This in turn will lead to increasing national competitiveness.

Roads are the backbone of a national transportation system. The National Planning Agency (Bappenas) noted that roads serve 84% of passengers, rail 7.3%, air 1.5%, sea 1.8%, and rivers only 5.3%. In terms of freight transport, 90.4% is carried by road, with the rest divided into ocean and rail, with 7% and 0.6% respectively. However, this mode has the potential for the large-scale transport of goods.

As the number of road users increases, the level of service gets worse. The arterial roads in one of the major islands of Indonesia, Sumatera, are the most affected. The main problems are severe congestion and road damage, particularly in arterial roads. This congestion is related to gaining access to different levels of road hierarchy such local roads, or because of a lack of sufficient road capacity, especially at intersections.

The problem with the inter-regional transportation system in Sumatra is the lack of rapid inland transportation modes and the lack of an efficient rail system. Whilst most passenger and freight transport is dependent on road, the alignment, width and the pavement structure of arterial roads is poorly maintained. As a result, the average travel speed on national roads is less than 30 km/h. For example, the travel time between Bakahueni and Banda Ache is more than 40 hours. In the case of freight travel, the travel time is even longer. There is also a lack of control of overloading, which results in pavement damage and the drainage system is also inadequate. Another problem is poor management of slopes, resulting in landslides. A typical example of traffic congestion on the in South Sumatera is shown in Figure 9.1.

Figure 9.1: Traffic congestion on Musi II Bridge in Palembang, South Sumatera

If an appropriate rail development plan is not introduced in Sumatra, then an optimal inter-regional transportation system, which guarantees proper mode shares between road and railway, needs to be established. This would need to meet the requirements of the primary function of an arterial road, which is to deliver traffic from collector roads to freeways, and between urban centres with limited-access roads and with fewer intersections.

A study *Establishment of a Master Plan for the Arterial Road Network in Sumatra Island* was conducted to improve the accessibility and mobility of the national roads in Sumatra through the establishment of a road network development plan that would prioritize and direct road network strengthening over the next 20 years.

9.1.2 Existing Condition

In 2009, the population of Sumatra was 49,615,400, or about 21.5% of the population of Indonesia. The average annual population growth was between 2000 and 20091.74%. The number of registered vehicles in Sumatra Island increased from 1,862,822 in 2005 to 2,785,427 in 2007, an annual growth rate of 22%. In 2008, the Gross Regional Domestic Product (GRDP) of Sumatra Island, without oil and gas, was Rp 354 trillion, approximately 20% of the total GRDP of Indonesia (Rp. 1,839 trillion). The annual growth rate of 6.69% between 2005 and 2008 was higher than the national average growth rate of 6.12%.

The vehicle composition measured at several survey locations was: motorcycles 54.9%, cars 24.6%, buses 2.7% and trucks 17.9%, whilst the average traffic volumes were 13,262 veh/day (Arterial), 7,976 veh/day (Collector 1), 5,076 veh/day (Collector 2) and 2,297 veh/day (Collector 3). The regions with the highest traffic volumes in each road hierarchy were: arterial in Aceh (16,243 veh/day), Collector 1 in Lampung (11,555 veh/day), Collector 2 in NAD (9,569 veh/day, and Collector 3 in Riau (4,322 veh/day). Traffic volumes on arterial road near the big cities, such as Medan, Pekanbaru, Palembang, are double those of other survey locations (15,596 veh/day).

In 2004, the Ministry of Public Works prepared the *Sumatra Toll Road Development Plan* in order to develop toll roads which could replace the existing arterial roads as a means of achieving sustainable economic growth in Sumatra. The toll road routes were established in consideration of regional development potential, and existing traffic volumes and pattern. The toll road system is in line with the existing road network. It aims to facilitate people-to-people exchange and the free flow of goods. It is also focused on increasing accessibility between the central city and peripheral areas and saving construction costs.

9.1.3 Road Function in Sumatera

The total length of national, and arterial and collector roads, in Sumatera is 5,756 km 5,812 km respectively. South Sumatera has the biggest proportion of arterial roads compared to the other provinces (see Table 9.1).

In terms of passenger travel, there are 787,467 trips per day in all provinces of Sumatra, including. 494,725 trips by cars and 292,742 trips by buses. Sumatra Utara has the highest travel volumes, 212,781 trips per day (which accounts for 27% of total travel in Sumatra). The total volume of cargo traffic in Sumatra is 752,371 tons per day, which is equivalent to 91,197 passenger car units (pcu) per day. Cargo traffic in Sumatra Utara is 179,197 tons per day (based on trip production), or 23.8% of all freight in Sumatra.

By 2039, it is estimated that there will be:

- 996,932 auto trips per day, a 101% increase compared to 2008
- 523,328 bus trips per day, a 79% increase compared to 2008
- 1,291,565 tonnes/day in freight movements, a 72% increase compared to 2008.

Table 9.1: National Road by Function in Sumatera 2012

Province	Length (km)	Arterial Roads	Collector
Aceh	1,803	538	1,265
Sumatera Utara (North Sumatera)	2,250	1,149	1,100
Sumatera Selatan (South Sumatera)	1,444	1,097	347
Sumatera Barat (West Sumatera)	1,213	675	538
Riau	1,134	791	343
Kepulauan Riau	334	132	202
Bengkulu	784	168	616
Jambi	936	729	207
Kepulauan Bangka Belitung	510		510
Lampung	1,160	475.574	684
Total	11,568	5,756	5,812

9.1.4 Design of Optimal Inter-Regional Road Network System

The national roads in Sumatra are composed of three south-north routes: eastern, central and western. There are about ten axial lines in the east-west direction. In terms of future travel demand, the intervals of road network for both axial directions need to be densely developed. To allow safe and speedy auto travel, it is desirable that the networks are straight rather than winding. The links also need to have a sufficient number of lanes to accommodate travel demand. In addition, the pavement needs to be strong enough to withstand the applied loads.

In addition, the length of roads in metropolitan areas which penetrate city boundaries is relatively long; congestions occurring inside the city is therefore more serious than in other regions. As a result, the efficiency of inter-regional transportation system is degraded. The solution is to convert the arterial level to inferior hierarchy, and then construct new bypass roads near the larger cities.

The main issues to be considered in terms of improving the road network are summarised in Table 9.2.

Table 9.2: Improvement of Network – Main Considerations

Properties	Improvement Directions	Main Consideration
Connection type	▪ Line expansion (new construction or elevation of existing roads ▪ Type improvement (straightening of connector roads between main regions)	▪ Regions where main traffic demand will occur in the future ▪ Connection distance major regions (ratio to straight distance)
Linearity of link	▪ Alignment improvement (straightening)	▪ Linearity of links
Width of link	▪ Road expansion (securing the number of lanes)	▪ Future travel demand
Pavement	▪ Improve load-carrying capacity (8 t to > 10 t)	▪ Features of future vehicles (weight, etc.)

9.1.5 Strategy for Improving Arterial Roads

In terms of the management of arterial roads over the next 20 years, the main issue is the construction of the Trans-Sumatra Toll Road (TSTR), which covers the whole area of Sumatra. To accomplish the TSTR project, it is necessary to attract private investment. If private investment cannot be attracted for economic reasons, then it will be necessary to increase government support for those sectors of toll roads. To improve the performance and safety of the national roads, it is important to improve the road alignment, especially winding roads in mountainous and hilly areas.

The completion of the 1×3 TSTR system within the planned period must be the most important priority in this master plan. The other important priority is the construction of the 3×15 national arterial road system with the TSTR. In addition, bypass roads near big cities also contribute to improving travel speed. Once these projects are completed, it should be possible to connect all the regions in Sumatra within 24 hours.

The target population justifying the construction of a bypass road is 200,000. However, the capital of a province would also be targeted, even if the population is less than 200,000. In these cases, the target cities include Tanjung Pinang and Pangkal Pinang. Overall, 17 cities would be targeted.

9.1.6 Impact and Economic Feasibility

The starting point for the selection and prioritization of any large-scale highway infrastructure project is the economic return expected from the development. As far as a feasibility study of identified road improvement options is concerned, the economic indicator used is the Economic Internal Rate of Return (EIRR), which is applied over the evaluation period of the road improvement sub-project, i.e. a 30 year period. Economic benefits include savings in vehicle operating costs (VOCs), savings in travel time for passengers, etc.

Travel time in Sumatera will be reduced when the arterial road network is improved. The travel time reduction effect of each alternative arterial road improvement plan is shown in Table 9.3. If the existing arterial road network is still in used in 2019, then 3.4 million hours will be needed for 1 million trips for one day in Sumatera. If the arterial road network is improved and the TSTR is constructed (alternative A), then the total travel time will decrease to 2 million hours, a 60% reduction. If the arterial road network is improved and the TSTR is not constructed (alternative B), then the total travel time will decrease to 2.2 million hours.

Table 9.3: Effect of arterial road improvement plan on travel time reduction (2019)

	Travel (trips/day)	Total Travel Time (hours/day)			Reduction Rate (%)	
		Existing Arterial (O)	Alt. with TSTR (A)	Alt. without TSTR (B)	1-A/O	1-B/O
NAD	143,752	361,148	233,088	239,261	38.2	33.8
Sumatra Utara	251,396	690,067	446,425	488,843	35.3	29.2
Sumatra Barat	159,398	492,107	298,401	314,063	39.4	36.2
Riau	134,638	341,407	192,191	214,199	43,7	37.3
Jambi	77,156	264,040	141,466	152,113	46.4	42.4
Sumatra Selatan	133,713	539,750	322,403	359,042	40,3	33.5
Bengkulu	60,012	196,350	125,182	133,263	36.2	32.1
Lampung	118,209	501,581	289,122	314,692	42.4	37.3
Total	1,078,274	3,386,450	2,038,278	2,25,475	39.8	34.6

The long-term impacts of the arterial road alternative A (after 2019) constructed at optimum level along with a toll road, is Rp 561 billion in Sumatera and Rp 868 billion in Indonesia annually. The value-added effect is Rp 304 billion in Sumatera and Rp 470 billion in Indonesia annually. The projected increase in employment is 7,000 in Sumatera and 12,000 in Indonesia annually. The effect of alternative B, where the arterial road is improved without a toll road, is Rp 378 billion annually in Sumatera and Rp 582 billion annually in Indonesia. The subsequent industrial value-added will be Rp 205 billion in Sumatera and Rp 316 billion in Indonesia annually. The projected increase in employment is 5,000 in Sumatera and 8,000 persons in Indonesia annually.

The results of feasibility analysis are presented in Table 9.4 and Table 9.5. Only two road sections (Lampung-Palembang and Pekanbaru-Medan) have positive economic benefits with the rest not feasible. In particular, the benefit/cost ratios of two road sections, Palembang-Bengkulu and Medan-Sibolga, are less than 1. Generally, the economic feasibility of the eastern routes located in flat areas is high, but the feasibility of the east-west routes is low.

With the addition of the toll road, the feasibility of the arterial road improves and the ranking is different. In this case, it is desirable to delay the operation of the arterial road which competes with the toll road. This would help to increase the traffic demand of the toll road and induce investment balance among regions. The study team ranked the road sections assuming a scenario of delay in arterial road operation, without causing travel inconvenience due to excessive traffic demand on the toll road. Based on the analysis of the investment priority of the road section, the Eastern route (main corridor) has high benefit-cost ratio and the roads around the main cities indicate high priority.

Table 9.4: Economic Feasibility of Alternative A

Corridor		Length (km) Toll	Feasibility Indices		
			B/C Ratio	NPV (Rp billion)	IRR (%)
Main Corridor	Lampung-Palembang	308	1.84	3,924	21.2
	Palembang-Pekanbaru	610	1.19	1,745	16.8
	Pekanbaru-Medan	353	1.46	2,436	18.9
	Medan-Ache	460	0.84	-855	13.2
Connecting Corridor	Palembang-Bengkulu	303	0.92	-481	14,1
	Pekanbaru-Padang	242	0.94	-428	14.4
	Medan- Sibolga	175	0.75	-1,138	12.1

Table 9.5: Economic Feasibility of Alternative B

Corridor		Feasibility Indices		
		B/C Ratio	NPV (Rp billion)	IRR (%)
Main Corridor	Lampung-Palembang	1.72	3,505	20.5
	Palembang-Pekanbaru	1.11	1,089	16.1
	Pekanbaru-Medan	1.37	2,019	18.2
	Medan-Ache	0.60	-2,903	9.8
Connecting Corridor	Palembang-Bengkulu	0.86	-891	13.4
	Pekanbaru-Padang	0.88	-922	13,7
	Medan- Sibolga	0.70	-1,416	11.4

Toll Road Development Plan

The Sumatera Island has eight Provinces and the capital of each province plays the central role in administrative, economic, and cultural activities. The highest priority should therefore be given to connect the capitals cities in the eight provinces with the toll road network. In this case, the basic structure of the network is based on the eastern route, connecting the six capitals in the eastern region.

9.1.7 Implementation Plan

The implementation plan is shown in Table 9.6 and Figure 9.2. The major projects proposed by this master plan are classified into three parts: construction of toll roads, improvement to arterial roads, and improvement in road management.

In the case of toll road construction, the following sub-projects need to be performed: normal preparatory works, such as feasibility study, detail design, and land acquisition.

The tasks to be performed in improving the arterial roads include alignment, drainage and slope structure. The construction of bypasses requires a review of the plans established by each Province. The implementation priority then needs to be determined. The introduction of 2+1 lanes has to be accompanied with the project focussing on an optimal introduction method adequate for the prevailing circumstances in Indonesia. As the gradual implementation of 2+1 lanes is desirable, a pilot project need to be performed in advance. The full implementation of 2+1 lanes in Sumatera would bring positive effects, such as a reduction in the budget and an enhancement in safety.

Table 9.6: Implementation Plan

Phase	Period	Corridor	Length (km)	Total Length (km)
0	2010-2019	Babatan-Tegineneng Indralaya-Palembang Pekanbaru-Dumai TebingTingi-Binjai	50 22 135 76	283
1	2015-2019	Lampung-Palembang Pekanbaru-Medan	358 548	906
2	2020-2014	Palembang-Pekanbaru Pekanbaru-Padang	610 242	852
3	2025-2029	Medan-Ache Palembang-Bengkulu Medan-Sibolga	460 303 175	938
Sum			2,979	2,979

Figure 9.2: Implementation Plan

The total budget for the construction of the toll road and the improvements to the arterial roads is shown in Table 9.7. The budget required for the toll road construction and the improvements to the arterial roads is Rp 145 trillion and Rp 160 trillion respectively. The other projects require Rp 305 billion, with Rp 5 trillion required during the preliminary period (present ~ 2014) and then Rp 87 trillion for Phase 1, Rp 115 trillion for Phase 2 and Rp 100 trillion for Phase 3.

Table 9.7: Total Budget for Toll Road Construction and Arterial Road Improvements (trillion Rp)

	Preliminary	Phase 1	Phase 2	Phase 3	Total
Toll road construction	4.528	37.088	55.312	48.955	145.883
Arterial road improvement	0	49.937	59,390	50.952	160.279
Other projects	283	22	0	0	305
Total	4.811	87.047	114,702	99.908	306.467

10 MAINTENANCE ISSUES

10.1 Making Roads Motorcycle Friendly: Case Study – Victoria, Australia

10.1.1 Introduction

Motorcyclists are among the most vulnerable road users in Victoria. A motorcyclist is almost 37 times more likely to be killed or seriously injured than a car driver or passenger (Henley and Harrison 2009). Although motorcycles comprise 3.7% of all registered vehicles in Victoria, they account for 13% of the road toll. On average, each year 44 motorcyclists are killed and 973 are seriously injured.

The engineering of the road surface and the road environment can contribute to the risk of a crash, and its severity, for all road users. However, for a motorcyclist these factors play a much greater role. Hazards for a motorcyclist in the road environment can be reduced by using motorcycle-friendly engineering products and road design, construction and maintenance practices.

To address the issues of road environment and road surfaces, VicRoads have developed a seminar *Making Roads Motorcycle Friendly* and associated publications, including a DVD. The seminar is designed for local government, road design and construction contractors, engineering students, utility providers and VicRoads employees.

10.1.2 Background/Literature Review

Making Roads Motorcycle Friendly was developed following a number of workshops involving experienced motorcycle riders and road construction engineers. These workshops identified motorcycle safety issues that were related to road design, construction and maintenance practices.

Relevant maintenance practices and standards were reviewed and the appropriateness of these standards for motorcyclists investigated. However, it is often the attention to detail within such practices which is important for the safety of motorcyclists; for example, cleaning oil or gravel off the road surface.

One of the actions which the investigation recommended was the implementation of a state-wide program of education and training for all staff involved in road design, construction and maintenance works so they could assess hazards from a motorcyclist's perspective.

The *Making Roads Motorcycle Friendly* package consists of a 2-hour multi-media presentation, two publications and a DVD. The first publication is an 18 page booklet titled *Making Roads Motorcycle Friendly – A Guide for Road Design*, *Construction and Maintenance.* The title of the second, smaller 8 page booklet is *Making Roads Motorcycle Friendly – A Guide for Working on Roads*.

During the seminar the booklets are read and discussed. The design of the package allows the seminar participants to take it back to their own organisations and train its staff.

VicRoads staff have delivered the seminar at its seven regional offices across Victoria; they have also conducted a number of lectures for engineering students at various Victorian universities.

10.1.3 Intended Outcome of Intervention

The aim of the *Making Roads Motorcycle Friendly* program is to improve the awareness and understanding of engineering staff about the design, construction and maintenance of roads so they are made safer for motorcyclists. There has been much interest, both nationally and internationally in the program.

VicRoads has shared the resource materials and provided training to the Western Australia Local Government Association (in collaboration with Main Roads Western Australia), the Roads and Traffic Authority of New South Wales and the New Zealand Transport Authority.

Each of these organisations is adopting *Making Roads Motorcycle Friendly* and will be educating road industry colleagues in their jurisdiction about how to apply the concept.

10.1.4 Description

As already discussed, the package contains two booklets and a DVD. The 18 page booklet, *Making roads motorcycle friendly – A guide for road design, construction and maintenance* provides comprehensive information about the design, construction and maintenance of road surfaces and roadsides. Topics include why motorcyclists are at risk, pavement markings, drainage and metal surfaces; and issues to be considered when maintaining roads to keep them safe for motorcyclists. The booklet is aimed at engineering and technical staff.

The smaller, 8 page booklet, *Making roads motorcycle friendly – A guide for working on roads* provides practical advice to on-site workers who are either constructing or maintaining roads to improve motorcyclist safety. There are tips on repairing road shoulders, potholes and cracks, and the correct use of warning signs.

The DVD shows the road from a motorcyclist's point of view. It includes examples of successful road engineering treatments that improve the safety of motorcyclists.

10.1.5 Results and Evidence

More than 500 delegates attended 20 seminars presented by VicRoads staff. When completed, the program of seminars was evaluated. In order to evaluate the program, the following issues were examined:

- evaluation forms completed immediately after each seminar
- the results of an e-survey completed by 56 respondents
- telephone interviews with five participants who had attended the seminar.

The results showed that the package was very popular with those who attended the seminars. The program was successful in raising their awareness and understanding as to how to make roads safer for motorcyclists.

Participants indicated a high level of awareness about why motorcyclists are at risk of a crash, and the impact that road design and surfacing type and condition can have on this risk.

On a scale of 1 (low awareness) to 5 (high awareness), the average response of participants, after attending the seminar, in terms of their awareness of motorcyclist crash risk was 4.55, and for the impact of road design, 4.22. Forty-two per cent of participants said they were now giving greater consideration to motorcyclists when planning road construction and maintenance works. Comments included 'attempting to select more appropriate surfacings' and 'looking more closely at maintenance on motorcycle routes'.

10.1.6 Costs and Return

The cost of developing the material and delivering 20 seminars was A$109,000. However, this cost will be lower when VicRoads provides the two booklets and DVD to other jurisdictions free of charge.

As many of the learnings from the initiative can be implemented within design, or as part of daily engineering practice. It is an extremely cost-effective method of improving road safety for motorcyclists.

Making Roads Motorcycle Friendly has been successful in educating engineers involved in road design, construction, maintenance and reinstatement works about the vulnerability of motorcyclists in the road environment. This increased awareness has resulted in those engineers applying work practices more effectively to address the road safety needs of motorcyclists.

Reference

Henley G & Harrison JE 2009, *Serious injury due to land transport accidents, Australia 2006-07*, Australian Institute of Health and Welfare: 23.

10.2 Sustainable Concrete Road Maintenance Solution with Enhanced Safety – Singapore

10.2.1 Introduction

The Land Transport Authority (LTA) Singapore maintains about 1.6 million m^2 of reinforced concrete roads and bus bays. Throughout the life cycle of the concrete road surface, defects such as top-down cracks, loss of skid resistance, loss of surface aggregates, etc. will develop, resulting in a poor riding surface which affects the safety of road users. However, in the past there was no effective method to treat these defects or to prevent them from developing into major surface defects. Concrete roads had to be reconstructed as a result of these severe non-structural surface defects.

Knowing that a lack of general routine maintenance will significantly affect the life span of a concrete road and its safe operation, in 2007 the LTA commenced development work to address the problem. The Fibre Reinforced Polymer Cement Coating (FRPCC) coating system, implemented in 2009, has proven to be successful and is now being broadly utilized in Singapore to rectify non-structural concrete road surface defects in an economical and effective way.

10.2.2 Literature Review

Concrete road surface lose skid resistance over time due to the polishing of the surface by traffic. Extensive wear may cause rutting where water can collect and cause hydroplaning (Transport Information Centre University of Wisconsin-Madison 2002). Surface texture, which is associated with skid resistance, can be restored through mechanical procedures, such as diamond grinding and (or) grooving or shot blasting (Ahammed and Tighe 2008). It can also be restored through the application of an asphalt overlay. However, restoring the texture through grinding the polished surface can damage the integrity of the concrete road over time and thus affect its life. In addition, grinding may be unsuitable at locations where the surface is cracked. Installing an asphalt overlay will result in an increase in maintenance costs; its use is also in conflict with the original intention of using concrete road surfaces to reduce the frequency of maintenance and minimise disruption to the traffic.

10.2.3 Objective/Outcome

The objective of the study was to trial the use of the FRPCC coating system to enhance the skid resistance of concrete road surfaces and to fix non-structural defects and hence save, or prolong, the need to reconstruct the pavement.

10.2.4 Examples of Success

The intersection between Tampines Street 72 and Tampines Avenue 9 was treated using FRPCC in July 2008. This was followed by a post-construction condition monitoring program for 12 months. Prior to the treatment, visual inspection of the road surface identified defects such as cracking, loss of aggregate and surface staining. Skid resistance testing conducted at different locations in the wheelpath using British Pendulum Tester revealed an average of reading of 37-48 BPN. Black FRPCC was laid to improve the visibility of the white road markings.

The FRPCC was applied to the surface according to the standard procedures. Site inspections were carried out at three-month intervals and skid resistance and pull-off testing was conducted at six-month intervals. The British Pendulum Test outcome was benchmarked according to the requirements spelt out in the LTA's *Material and Workmanship Specification* where newly-constructed concrete road surfaces are required to achieve a minimum BPN reading of 55. After the application of the FRPCC, the skid resistance values ranged between 56 and 75 BPN.

The latest skid resistance testing carried out in January 2011, or 2.5 years after the installation of the FRPCC, indicated that the skid resistance value ranged from 60 to 65 BPN. A visual inspection did not reveal any defects such as cracking, debonding or surface peeling.

10.2.5 Example of Failures/Shortcomings

Lessons were also learnt from a project carried out in Jalan Riang. The service road serves a number of the shops and had shown significant defects with spalling of aggregates and loss of skid resistance.

During the application of the FRPCC there were several occasions of rainfall. The application was then subsequently suspended; however, during the reapplication process, the previously-laid FRPCC was not completely removed.

Debonding in the form of surface peeling was observed two years after the application as illustrated in Figure 10.1.

Figure 10.1: Existing condition of Jalan Riang

An investigation identified that the failure is due was related to the debonding of the initial layer of the FRPCC as its bonding strength was weakened due to the effect of rain during the application process.

As a result, the authority spelled out in the construction procedure that the application of FRPCC was strictly forbidden when weather conditions were not favorable and also that thorough removal of the coating is required if it is affected by rain or water. Reconstruction work or resurfacing work must be performed on the properly-treated concrete road surface.

10.2.6 Evidence of Before-and-After Change

The surface condition before and after the application of the FRPCC treatment is shown in Figure **10.2.**

before **after**

Figure 10.2: Condition of intersection before and after application of FRPCC

10.2.7 Cost Estimate

Using FRPCC to treat the concrete surface can achieve substantial cost savings as it provides protection to the concrete structure thus increasing its life span. The benefit of applying the FRPCC at this location, in terms of tangible cost savings, is shown in Table 10.1.

$$\text{Net Present Value} = (0 - 9{,}750)/(1 + (3/100))^5 + (29{,}250 - 9{,}750)/(1 + (3/100))^{10} + (0 - 9{,}750)/(1 + (3/100))^{15} + (29{,}250 - 9{,}750)/(1 + (3/100))^{20} = \$\ 10{,}638$$

The Net Present Value calculation assumes a discount rate of 3% and a design life of 25 years. However, the majority of the concrete roads in Singapore are reconstructed due to the deterioration of the surface defects 10 years after the construction. The life span of the concrete road used in this calculation was therefore 10 years. The area of the FRPCC-treated sections at the intersection of Tampines Street 72 and Tampines Avenue 9 is 390 m^2 and the current unit rates for concrete roads and FRPCC are $\$75/m^2$ and $25/m^2$ respectively. The FRPCC will be re-coated every five years.

Table 10.1: Cost Comparison (Remove and Reconstruct / FRPCC)

Operation Year	Cost of Operation		NPV
	Remove and Reconstruct	FRPCC	
Year 1	-	-	-
Year 5	-	$9,750	-$8,410
Year 10	$29,250	$9,750	$14,509
Year 15	-	$9,750	-$6,258
Year 20	$29,250	$9,750	$10,797

The utilization of FRPCC at this above location is provide the authority S$10,638 worth of tangible savings in the life cycle of the concrete road. However, it should be noted that there are also intangible savings to road users such as the early opening of the work site to traffic within 12 hours as compared with 10 days with reconstruction, and improved skid resistance and safety. These are not included in the cost analysis.

10.2.8 Recommendations

FRPCC enables LTA's engineers to manage their concrete roads in a more efficient way. The relatively low expenditure has provided significant returns in the form of improved road condition and reduced traffic congestion. Moreover, the FRPCC reduces the dependency on natural aggregates and the shorter treatment time significantly minimizes the disruption to the traffic.

References

Transport Information Centre, University of Wisconsin-Madison 2002, *Pavement surface evaluation and rating: concrete road*.

Alauddin Ahammed, M & Tighe, SL 2008, *Concrete pavement surface texture and multivariable frictional performance analysis: a North American case study*.

Land Transport Authority Singapore 2008, *Material and workmanship specification*.

10.3 Managing Road Safety from a Road Maintenance Perspective in Malaysia

The increasing length of roads requires the Government of Malaysia to allocate a certain amount of money for maintenance. For the 19,000 km length of Federal roads, approximately RM550 million[4] per year has been spent over the last five years. The maintenance of Federal roads in Peninsular Malaysia and East Malaysia was privatized in 2001 and 2003 respectively under the strict supervision of the Public Works Department (PWD). The proactive and systematic approach to road maintenance that is applied has ensured the functionality and good condition of Federal roads in Malaysia.

The length of roads in Malaysia had increased to 90,000 km by 2009 and the number of registered vehicles, inclusive of private and commercial vehicles, has also continuously increased. As at 2008, there were 11,227,144 registered drivers, 7,966,525 registered private vehicles and 1,063,767 registered commercial vehicles.

The increasing length of roads and the number of vehicles has contributed to an increasing number of road accidents throughout the country. The number of accidents has been increasing constantly for the past ten years. The most alarming statistic is the number of deaths, which has remained constant at 6,200 since 2003, or an average of 17 deaths per day, making it among the top killers of Malaysians.

The increasing number of accidents and the high loss of life has raised concerns about road safety in Malaysian society. As the custodian of roads in Malaysia, the PWD faces constant scrutiny regarding its role in addressing this situation. In response, the PWD is actively planning and implementing road safety in its operations and also actively promoting its initiatives to the Malaysian public.

The PWD has initiated various activities which either directly or indirectly contribute to road safety. Over time, some of these activities have come to be viewed as mundane routine activities inspite of their importance. This has created a dilemma about whether the programs are important enough to be executed when there is an unknown or uncalculated impact on road accident reductions.

The Road Facilities Maintenance Branch of the PWD has spent about RM550 million a year for the past three years on the maintenance of Federal roads. There are 20 specific activities carried out every year, with ten of them being directly related to road safety. Activities such as re-painting road line-marking, sealing road shoulders, and the installation of new barriers, road studs and flexible posts are typical activities related to improving road safety. However, the Road Facilities Maintenance Branch has not limited its involvement to these routine activities and some other programs have been planned and carried out which are dedicated to road safety.

There are many locations where junctions need to be upgraded due to the rapid growth in the Malaysian economy, and hence traffic. Improvement works include the construction of islands or gores, the construction of acceleration/deceleration lanes, pavement widening and improvement of delineation at the junction area including the erection of signs or the installation of traffic signals. The upgrading of junctions usually requires engineering design, the re-alignment of the existing road, increasing the number of lanes, the provision of pedestrian crossings, etc. For works costing less than RM200,000, the implementation is managed by the Road Facilities Maintenance Branch. However, if the cost is higher and the scope of works larger (e.g. the upgrading of a junction requiring a new design), then the project is usually managed by the Road Branch.

An example of an improvement to a road junction is shown in Figure 10.3.

4

before **after**

Figure 10.3: Example of improvement to a road junction

Often the public will request that street lighting be installed to improve visibility while driving at night. Street lighting can contribute to a reduction in accidents, especially motorcyclist accidents. Each year, at least RM10 million is allocated for the installation and maintenance of street lighting.

Hundreds of new accident locations are identified each year. The PWD has initiated a program that provides short-term mitigation treatments at locations registered on an accident locations database, in an attempt prevent further accidents. In addition to locations recorded in the database, locations which are prone to accident based on the evaluation of PWD District Engineer are also considered for treatment. Treatments include the installation of signs and guardrails, resurfacing, improving delineation, etc. The program commenced in 2004 and, by 2008, 856 locations had been treated at a cost of RM33.3 million. This has resulted in re-occurrences of accidents at these locations being as low as 1%.

In order to demonstrate the commitment of senior management to road safety, an annual KPI has been set for PWD's Director General. This KPI is the annual expenditure on maintenance allocated to the road safety program. Up to December 2009, RM80.73 million had been allocated to road safety programs under the Road Maintenance Facility Branch. Of this, RM80.59 million had been spent on the road safety program, indicating 99.83% achievement.

At the Ministry level, one KPI relates to reducing the numbers of victims at ten locations which account for the highest numbers of accident victims. A total of 55 victims, including deaths, severe injuries and mild injuries, has been set as a target for these locations. A special program has been planned and designed to treat these locations, at an estimated cost from RM 200,000 up to RM 800,000. Works were undertaken between July and November 2009. Up to March 2010, only one accident with one minor injury had been recorded. The post-treatment accident monitoring period is three years, ending in December 2012. Another 30 locations were treated in 2011. The monitoring and evaluation of the outcomes is currently under way.

Malaysia is comprised of three major ethnic groups with different cultures and religions. Some cultural and religious celebrations have been identified as periods during which high numbers of accident and fatalities are recorded each year. This is due to Malaysian citizens taking leave to return to their hometowns to be with family during these festive seasons. The two most popular festive seasons are Eid Mubarak for Muslims and Chinese New Year for ethnic Chinese. Other Malaysians also take leave during these periods. During these festive seasons, the number of vehicles on the road increase rapidly.

In 2005 a program called Integrated Operations (OPS BERSEPADU) was launched. The objectives of this program are to reduce road accidents during this period through enforcement, awareness campaigns and the encouragement of a safe driving attitude. This operation usually runs for 15 days, seven days before the actual date of the festival and seven days after. Up to Chinese New Year in February 2010, there were 21 instances of this operation taking place, with mixed results.

Malaysia has been selected from among ASEAN countries to carry out a pilot study of this program due to a strong commitment to road safety by both government and the private sector. In 2007, 3,688 km of highways and federal roads were surveyed and rated. Most of the surveyed roads were rated as three star and below, a three star rating meaning that the road is undivided, suitable for 80 km/h travel speed, has clearance to roadside hazards, good delineation, is straight and has sealed shoulders. The study proposed an initial investment of RM550 million under the 10^{th} Malaysia Plan. A further IRAP program has been proposed for all federal roads at a cost of RM6 million and it is hoped that this will be carried out as part of the 10^{th} Malaysia Plan.

In summary, many plans and programs have been implemented by the PWD which contribute to road safety. The PWD realizes that, whilst some routine maintenance works are mundane activities, the accident problem would be worse if these activities were not undertaken. Comprehensive programs with clear outcomes have also been formulated and show promising results in terms of lives saved. Inputs such as the IRAP study provide valuable input in planning future road safety programs. Other areas that contribute to road safety, such as vehicle safety and road user behavior, cannot be excluded in planning road safety. Collaboration with other government agencies will help the PWD to prioritize and implement the most appropriate counter-measures.

11 ROAD DESIGN

11.1 Incorporating Safe Road Design into Projects: Case Study – Western Australia

11.1.1 Introduction

The scope of the A$650M New Perth-Bunbury Highway road construction project included 30 km of freeway construction and 40 km of dual carriageway highway construction. It was Main Roads Western Australia's (MRWA) highest value road project. An alliance procurement model was established to encourage innovation and to align the goals of the alliance partners.

Significant focus was placed on road safety. The minimum condition of satisfaction set for the project was a 10% reduction in serious injury and death compared to 2007. WA best practice and the aspiration set for the project was zero deaths within the first five years of operation[5].

In August 2007, the Commissioner of Main Roads accepted a recommendation from the Stakeholder Reference Group and established the independent Safe Systems Working Group (SSWG), which was chaired by the respected engineer, Mr Sarkis Petrossian (Engineers Australia). Membership of SSWG included the project's Engineering Manager, Main Roads' Executive Director responsible for road safety and Executive Directors from the Office of Road Safety and the Royal Automobile Club. The role of the SSWG was to assist the Southern Gateway Alliance to meet the minimum condition of satisfaction and aspire towards the vision of zero serious injuries and deaths on the road network. It reported to the Commissioner of Main Roads.

The following case study documents the processes and innovations of SSWG, including further knowledge gained from subsequent SSWG's established and arising from the success of the initial group.

11.1.2 Best Practice Review

Research was undertaken to define 2007 best practice for freeway and dual-carriageway highway construction. It was identified that the existing freeway and highway beyond the project, which the project was conceived to connect, represented the most relevant definition. Accordingly, road safety statistics from the preceding five years were extracted[6]. From these statistics it was determined that, if no road safety advances occurred, then there would be in the order of 12 deaths and 72 serious injuries during the first five years of the operation of the New Perth Bunbury Highway[7] or a combined 16.8 per year.

The project design team was engaged and the gap between the road safety objective and design principles identified. In general, the designers were unsure as to what tangible methods they might be able to apply that would improve current best practice road safety because it was a given that there would be appropriate compliance with the current standards and guidelines. An independent consultant recommended consideration of AusGuideline 3.3[8] which provides a structured framework for translating goals into tangible outcomes, outputs and inputs. This recommendation was adopted and the *'Vision Zero' Logical Framework*[9] was developed.

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5 New Perth Bunbury Highway Stakeholder Reference Group Workshop 24 February 2007, Traffic Operations Centre, East Perth, Western Australia.

6 MRWA's road data management system, Reporting Centre.

7 Commissioner of Main Roads, Presentation to the Vision Zero Value Management Workshop for New Perth Bunbury Highway at the project Stakehill Office, 27 November 2007.

8 AusGuideline 3.1: The Logical Framework Approach, AusAid, Australian Government, October 2005.

9 http://www.mainroads.wa.gov.au/UnderstandingRoads/RoadSafety/Pages/SafeSystems.aspx.

In developing the framework, international best practice with respect to road safety strategy was considered. High value was placed on Sweden and The Netherlands[10], where best practice road safety statistics were observed. Also, the Australian Road Assessment Program was referenced in the framework.

11.1.3 Intended Outcome of Intervention

The key intervention, the *'Vision Zero' Logical Framework* (which was later improved and retitled the *Towards Zero Framework* during the third iteration of the SSWG) provides a structured, risk-based approach to road design and engineering. It seeks to provide the following outcomes:

- collision energy/impulse reduced to within human tolerances for eliminating serious injury and death through sustainable solutions, when foreseeable crash scenarios arise
- optimal driver engagement and care observed, particularly at identified 'Towards Zero Risks' without sustainable solutions ('Self Explaining Roads').

In order to achieve these outcomes, the framework firstly focuses attention on the key serious injury and death crash risks ('Towards Zero Risks'):

- run-off-road and head-on crashes where vehicle speed exceeds 70 km/h
- side impact crashes where vehicle speed exceeds 50 km/h
- unprotected road user crashes where vehicle speed exceeds 30 km/h.

Secondly, in recognising that road authorities need to best utilise their finite resources to meet a diverse range of objectives, the framework provides a hierarchy of control for the treatment of hazards as follows:

1. Sustainable solutions: forgiving road and roadside design features that prevent serious injury and death are applied within a sustainability context that considers the competing demands of the community, government and road authorities.
2. Real time risk reduction: pre-crash warning/intervention systems (e.g. Intelligent Transport Systems, audible road marking) are applied wherever reasonable to provide driver specific warnings and support to significantly reduce the remaining 'Towards Zero' risks and crash risk in general.
3. General risk reduction: road and roadside engineering, education and enforcement to reduce crash risks and encourage optimal driver behaviour and alertness.

Accordingly, the framework provides clarity to road safety practitioners regarding the key serious injury and death risks and treatment selection.

11.1.4 Success or Failure

Upon the adoption of the *'Vision Zero' Logical Framework*, a 'Value Management' workshop was conducted for the New Perth-Bunbury Highway project. The independent members of the SSWG contributed international expertise to the event. Most notably, Roger Johannson of the Swedish Road Administration attended the workshop and presented Swedish best practice road safety. The Commissioner of Main Roads presented the *'Vision Zero' Logical Framework*, with the framework applied to the project's Towards Zero crash risks. The workshop was successful in identifying numerous suggestions at each level of the hierarchy that could be considered for inclusion in the project[11].

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[10] Advancing Sustainable Safety, National Road Safety Outlook (The Netherlands) 2005-2010, SWOV, Leidschendam, 2006.

[11] Value Management Workshop Summary, 27 November 2007, http://www.mainroads.wa.gov.au/UnderstandingRoads/RoadSafety/Pages/SafeSystems.aspx

The project considered the suggestions, adopted those that were sustainable within the existing project parameters and made further recommendation to MRWA in terms of the adoption of a number of initiatives that were beyond the project parameters and additional funding was approved. Accordingly, the application of the framework was considered to be successful.

11.1.5 Project Evaluation

The New Perth Bunbury Highway was opened to traffic in September 2009, limiting the crash data available for analysis. The crash statistics for the 2010 calendar year included two fatalities and ten hospitalisations[12], which represented a 28.6% reduction in serious injury and death compared to 2007 WA Best Practice.

The context of the road's operation is that the northern 20 km (freeway) has a 100 km/h speed zone and a 25,000 veh/day[13] traffic volume. The southern 50 km (10 km freeway, 40 km dual carriageway highway) has a 110 km/h speed zone and 12,000 veh/day[14]. Street lighting has only been provided at interchanges and at major at-grade intersections.

The design is largely traditional with wide clear zones. However, audible (tactile) edge-lining was installed the full length on both sides of each carriageway and wire rope barriers were installed to protect bridge piers, abutments and significant hazards located at the clear zone boundary.

Detailed analysis of crashes is to be undertaken after two years of data is available.

11.1.6 Results

While further study is required, the crash data to date indicates a reduction in serious injury and death compared to previous WA Best Practice. Even in advance of the data, the process was considered to be a success. This resulted in further SSWG's being established for the following projects: Mandurah Entrance Road (A$155M), Roe Highway Extension (A$450M), Gateway WA (A$900M) and Great Northern Highway realignment in Port Hedland (A$180M). Also, the *'Vision Zero' Logical Framework* has been improved and renamed the *Towards Zero Framework* (see Table 11.1); it is consistent with the State and MRWA's road safety strategies.

The Mandurah Entrance Road (named Mandjoogoordap Drive on opening) is 6.45 km long. Since opening in October 2010, there has not been a serious injury or death[15]. The context of the road's operation is that the speed limit had been increased from 80 km/h to 90 km/h by the end of 2010 and the traffic volume is 9,000 veh/day[16]. The design is considered to be innovative with median barrier the full length of the road and extensive application of roadside barriers. No vegetation clearing has occurred beyond the road formation, improving the aesthetics of the road.

At the major intersection with Mandurah Road, a feature roundabout with signature art piece has replaced the originally proposed traffic signals (at reduced cost to the project), and the curved approaches to the roundabout encourage vehicle speed reduction ahead of the conflict points (see Figure 11.1).

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[12] Data obtained from Main Roads' IRIS Reporting Centre, road safety statistics.

[13] Data obtained from Main Roads', Asset Network Information Branch.

[14] Data obtained from Main Roads', Asset Network Information Branch.

[15] Data obtained from Main Roads', Road Safety Branch.

[16] Data obtained from Main Roads', Asset Network Information Branch.

Figure 11.1: Mandjoodoorgap Drive–Mandurah Road intersection adjusted from traffic signals to a roundabout, which enabled signature public art to be installed

The Roe Highway Extension project involves the construction of 5 km of freeway-standard dual carriageway, which traverses sensitive environmental areas, and a freeway-freeway interchange. The concept design phase has been completed with the extensive involvement of the SSWG, which enabled a significantly reduced road footprint and road safety improvements. In addition, the innovative reverse diamond (also known as a diverging diamond) interchange has been included at a major interchange. This is expected to improve traffic efficiency and reduce serious injury and death risks as it results in just two significant conflict points, both with the higher (70 km/h) threshold. In addition, an enhanced road safety audit structured around the Logical Framework crash risks and the hierarchy of control was completed.

11.1.7 Costs and Return

An additional A$9M was assigned to the New Perth Bunbury Highway budget to incorporate additional road safety features. A learning from the project was that the application of the *'Vision Zero' Logical Framework* should occur from project planning, because decisions were made that prevented a number of suggestions (such as bringing the two carriageways together to create a '2+2' road cross-section).

The Mandurah Entrance Road project was delivered A$5M under its budget with no additional funding allocated for road safety. Rather, the additional road safety features were achieved through project cost offsets. For example, the road safety barrier reduced clearing as none was undertaken beyond the road formation and the batters were steepened. At the eastern end, after the rail left the median, the carriageways were brought together, thus reducing embankment volume and clearing costs. The signature roundabout intersection was also completed for a lower cost than the originally planned traffic signals. As the entire project's costs and savings are reported together, it is unclear whether the road safety innovations paid for themselves or if other capital cost savings contributed.

Table 11.1: 'Towards Zero' Framework

CRITERION	NARRATIVE	INDICATOR	VERIFICATION
GOAL: Towards Zero Road Safety			
Road planning, design, construction, operation and maintenance that enables realistic and ongoing pursuit of zero deaths and serious injuries, in spite of human fallibility, due to sustainable solutions preventing the possibility.	▪ The most progressive international and national road safety policy directions are based on the idea that serious injury and death on the road network should not be tolerated. These policies include Sweden's Vision Zero, The Netherlands' Sustainable Safety and Australia's Safe System. The Towards Zero road safety strategy for WA 2008-2020, which received bi-partisan support in State Parliament, also includes these principles and recommends a safe system transformation of the network. ▪ The Towards Zero framework increases the road design and engineering focus on the key serious injury and death crash risks and encourages the development of sustainable solutions, within a three-tier hierarchy of control, recognising the competing demands for limited road authority resources. ▪ The Framework has developed within the independent Safe Systems Working Groups established for major road projects in Western Australia and was originally titled the Vision Zero Logical Framework (New Perth Bunbury Highway project).	▪ Number of crashes causing serious injury and death per million vehicle kilometres travelled. ▪ Extent of application of sustainable solutions (validated by crash statistics) across the project in each of the Towards Zero crash risk areas. ▪ Drivers are observed to take appropriate care, particularly at locations where Towards Zero risks were unable to be reasonably prevented, through the road operation lifecycle. ▪ Ongoing public satisfaction with road safety.	▪ Crash statistics ▪ Crash investigations and assessment of potential consequences ▪ Records relevant to Towards Zero policy implementation ▪ Road safety audits ▪ Sustainability assessments ▪ Community and stakeholder survey
OUTCOME			
▪ Collision energy/impulse reduced to within human tolerances for eliminating serious injury and death through sustainable solutions, when foreseeable crash scenarios arise. ▪ Optimal driver engagement and care observed, particularly at identified Towards Zero risks without sustainable solutions. ▪ Public trust in road safety management.	▪ Sustainable solutions reduce potential collision energy/impulse to within human tolerances for serious injury and death during possible crash scenarios and in anticipation of human behaviour. ▪ Design and operation features promote optimal driver engagement and care to reduce the risk of serious injury and death, particularly at the Towards Zero risks: ▪ run-off road and head-on crashes where vehicle speed exceeds 70 km/h ▪ side impact crashes where vehicle speed exceeds 50 km/h ▪ unprotected road user crashes where vehicle speed exceeds 30 km/h. ▪ Positive community response after project opening in relation to road safety.	▪ Through collection of post road opening operational speed data: ▪ percentage of Towards Zero risks mitigated with sustainable solutions ▪ percentage of Towards Zero risks mitigated with real time risk reduction alternatives (decrease in driver speed observed). ▪ Drivers are observed to take appropriate care, particularly at locations where Towards Zero risks were unable to be reasonably prevented, post project opening. ▪ Public satisfaction with road safety after project implementation.	▪ Post implementation project review and close out reporting. ▪ Post implementation traffic data. ▪ Community and stakeholder survey.

OUTPUTS			
Road safety treatments applied in accordance with the 'Towards Zero' framework hierarchy of control: ▪ sustainable solutions ▪ real time risk reduction ▪ general risk reduction.	Towards Zero Framework Hierarchy of Control: ▪ Sustainable solutions: Forgiving road and roadside design features that prevent serious injury and death are applied within a sustainability context that considers the competing demands of the community, government and road authorities. ▪ Real time risk reduction: pre-crash warning/intervention systems (e.g. Intelligent Transport Systems, audible road marking) are applied wherever reasonable to provide driver specific warnings and support to significantly reduce the remaining Towards Zero risks and crash risk in general. ▪ General risk reduction: road and roadside engineering, education and enforcement to reduce crash risks and encourage optimal driver behaviour and alertness.	▪ Extent of Towards Zero road planning/design: Prevention of frontal and transverse conflicts between all road users; where possible conflicts exist, the road geometry, road features and roadside is designed to ensure: ▪ at unprotected road user conflicts, vehicle speed exceeding 30 km/h through conflict points is prevented ▪ at transverse conflicts, vehicle speed exceeding 50 km/h through conflict points is prevented ▪ at frontal conflicts, vehicle speed exceeding 70 km/h through conflict points is prevented. ▪ Extent of application of real time risk reduction measures to Towards Zero risks and to mitigate general crash risks. ▪ Extent of application of general risk reduction measures at Towards Zero risks and to mitigate general crash risks.	▪ Safe Systems Working Group review and discussion of Towards Zero road safety in planning and design. ▪ Management system, design and risk management records. ▪ Road safety audits. ▪ Value management reports. ▪ Sustainability assessments. ▪ Community and stakeholder feedback.
INPUTS			
▪ Towards Zero risk identification and mitigation. ▪ Safe Systems Working Group resources and recommendations. ▪ Road safety audits structured around the Towards Zero framework hierarchy of control. ▪ Involvement of Towards Zero experts. ▪ Training in Towards Zero principles and approaches.	▪ Risk management that identifies Towards Zero risks and seeks sustainable solutions through value management and engineering. ▪ Open engagement with the Safe Systems Working Group to maximise Towards Zero project outcomes. ▪ The traditional road safety audit procedure is structured around the road engineering component of Level 3 of the Towards Zero framework hierarchy of control. ▪ Involvement of independent Towards Zero experts to provide ideas and training.	▪ Road safety management system that is structured in accordance with the Towards Zero framework. ▪ Safe Systems Working Group rating of processes engaged. ▪ Road safety audit primary focus upon identifying Towards Zero risks with close out considerations categorised in accordance with the Towards Zero framework hierarchy of control. ▪ Engagement of the Safe Systems Working Group and preservation of the group's independence.	▪ Road safety management system audit. ▪ Survey of Safe Systems Working Group. ▪ Road safety audits - corrective action responses. ▪ Training, meetings and workshop records.

11.2 Road Design Issues in Hilly Terrain in Malaysia: A Maintenance Perspective

11.2.1 Introduction

In the development of road networks to secure a comfortable and conducive environment to the road user, maintenance management is one aspect that should be given particular emphasis and attention on roads in hilly terrain. Each design should be carried out based on current needs in addition to the need to reduce road accidents, especially for areas that are hubs of economic growth such as roads linking tourism areas.

11.2.2 Issue to be Addressed

Road design

The main cause of failures of roads in hilly terrain can be related to design errors, including slope stability, drainage and the location of access points. A typical problem related to (lack of) slope stability is shown in Figure 11.2.

Figure 11.2: Typical problem related to slope stability in hilly terrain

The successful design of the slope requires geological information and site characteristics such as the properties of the soil/rock mass, slope geometry, groundwater conditions, alternation of materials by faulting, joint or discontinuity systems, movements and tensions in joints and earthquake activity.

The selection of the correct analysis technique depends on both site conditions and the potential mode of failure; careful consideration must be given to the varying strengths, weaknesses and limitations inherent in each methodology.

Most Malaysian engineers design slopes using simplified specifications. All of the design calculations are based on ‘rules of thumb’ of works without consideration of the prevailing conditions at the candidate site. The designer tries to restrict the need for earthworks and to minimize the disturbance to slopes by following the natural contours of the hilly terrain. This will influence the gradient and geometry of the road.

The design of drainage structures is based on hydrology and hydraulics. The former addresses the occurrence and form of water in the natural environment (precipitation, stream flow, soil moisture, etc.) while the latter addresses the engineering properties of fluids in motion. Cut or fill failures, road surface erosion, and weakened subgrades followed by a mass failure are all products of inadequate or poorly-designed drainage. The excessive runoff is not taken into consideration during design.

Most designs are based on standard drawings. However not all standard drawings are complete and customized. Therefore, most of the projects that are carried out in hilly terrain have no access to maintenance works or lack a cascade drain as a possible access solution or forgiving device.

Finally, the lack of standards for the provision of additional safety features such as escape ramps can be a design deficiency. Emergency escape ramps enable vehicles that are having braking problems to stop safely. They are typically long lane located adjacent to a road with a steep grade and composed of sand or gravel ('arrester beds'). They are designed to accommodate large trucks.

11.2.3 Intended Outcome of Intervention

The main outcome of the interventions was to ensure easy access for slope maintenance.

11.2.4 Improvements

Short-term Improvements

The initial steps that need to be taken in the event of a slope failure, and during the design stage, are as follows:

- The use of heavy duty plastic sheets (Figure 11.3) to prevent continuing erosion of a slope that has failed; associated traffic safety measures such as caution signs and barrier railings are also required.

Figure 11.3: Use of plastic sheets to prevent slope erosion

- The use of cast-in-situ drainage on reclaimed slopes designed in accordance with design specifications.

- The design of slope protection such as turfing and nailing in accordance with contract drawings.

- The provision of suitable road access for the maintenance works, including the provision of stairs to check the slope, berm and toe drain where the terrain is almost vertical.

Long-term improvements

In the long term, the following steps need to be taken:

- The design of each area of a slope should be referred to a specialist service that investigates the classification and soil strength; it should not be undertaken in accordance with existing practice of by 'rule of thumb'.

- As-constructed drawings have been enshrined in the PWD Quality Management System. Any changes to the drawings should be approved by the Superintending Officer when work is completed and the site approving officer should be responsible for ensuring as-built drawings are provided. Proposals for the retention fund are not released until after the work is fully completed. In addition, a checklist is used to ensure the as-built drawings are provided in good order.

11.2.5 Specific Intervention/Regional Intervention

A typical vertical ladder on a rock slope is shown in Figure 11.4 while a typical cascade drain with hand railing in shown in Figure 11.5. These are good examples of access points located in hilly terrain for maintenance purposes.

Figure 11.4: Typical vertical ladder on a rock slope

Figure 11.5: Typical cascade drain with hand railing

A typical emergency escape ramp is shown in Figure 11.6. There are currently no standard guidelines for the design of escape ramps in Malaysia. However, considerable experience with ramps constructed on existing highways from other countries has led to the design and installation of effective ramps that are saving lives and reducing property damage.

Figure 11.6: Typical emergency escape ramp

11.2.6 Conclusions

Most road failures in Malaysia are shallow and small-scale failures caused by surface infiltration or erosion during heavy rainfall. These failures are often related to deficient or poorly-maintained slope surface covers and drainage provisions. Therefore, visual inspections and subsequent maintenance recommendations should be directed principally towards measures that minimise the infiltration of surface water and scouring by surface water flow.

The provision of an effective surface protective cover and adequate drainage, along with proper maintenance, is essential for the continued stability of man-made slopes and retaining structures.

With a monitoring and reporting mechanism in-place, road maintenance will be more efficient and effective as the routine inspection reports provides a check-list of items that need to be checked and rectified if necessary.

11.3 Road Design Issues Associated with Rangiriri 2+1 in New Zealand

11.3.1 Issue

A 9 km long section of New Zealand's primary arterial, State Highway 1, which carries approximately 15,000 vehicles per day, had a high severity crash record of seven crashes resulting in death and five crashes resulting in serious injury over a five-year period between 1999 and 2004. Of the seven fatal crashes, six resulted from head-on crashes.

This section of highway was a single, undivided carriageway with short overtaking lanes, nestled between sections of dual, median-divided carriageways.

11.3.2 Specific Intervention

The intervention adopted was to widen the carriageway from 12.2 m to 15.5 m and install a wire rope medial barrier within a 1.5 m narrow paved median, plus side barriers to protect roadside hazards where appropriate. The passing lanes were reconfigured to give two longer (3 km) passing lanes, effectively producing a 2+1 arrangement. Some photos of the new configuration are shown in Figure 11.7.

Figure 11.7: Rangiriri 2+1 road design

11.3.3 Intended outcome of intervention

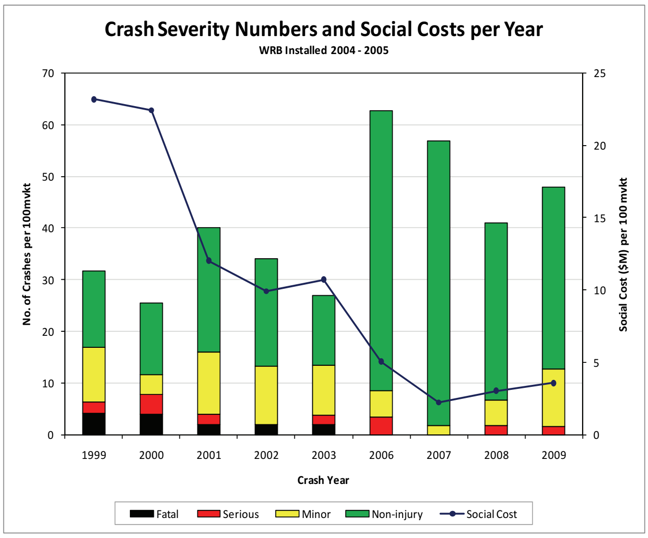
The intended outcome was to reduce the frequency of high severity crashes, in particular head-on crashes where an 85% reduction was predicted. However, based upon the Swedish 2+1 experience, it was predicted that the overall crash rate would increase due to low severity barrier strikes, which were estimated to occur every 10 days at a rate of one strike per 1.5 million vehicle-km.

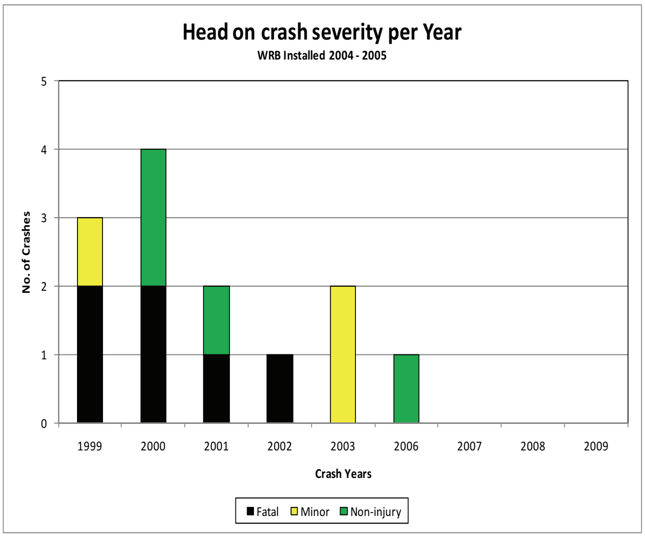
11.3.4 Results

The crash severity and head-on crash data over the period from 1999 to 2009 is presented in Figure 11.8, whilst a comparison of predicted and measured performance is presented in Table 11.2. The project has been a success with no reported fatal crashes and only four serious crashes in the four years (2005-2009) following the completion of construction and only one head-on crash resulting in no injuries. Overall there has been a 65% reduction in the rate of fatal and serious crashes. However, as predicted, there has been an increase in non-injury crashes through numerous barrier strikes although the rate of these is marginally lower than predicted.

11.3.5 Costs and Returns

The project cost approximately NZ$8.0 million. The annual average social cost of the crashes was estimated at NZ$7.85M pre-installation reducing to NZ$2.09M post installation, a saving of NZ$5.76M per annum. Even accounting for the cost of barrier repairs (approximately NZ$70,000 per annum), the project paid for itself within two years.





Crash Numbers & Severity **Head on Crash Severity**

Figure 11.8: Crash severity and head-on accidents before and after installation of treatments

Table 11.2: Comparison of Predicted and Measured Performance

Performance Indicator	Predicted Performance	Measured Performance
Reduction in head-on crashes	85%	90%
Barrier strike rate interval	1 every 10 days	1 every 10.4 days
Barrier strike rate	1/1.5 Mvkt	0.91/1.5 Mvkt

Crash Rate Per 100 million veh-km	Pre Installation (1999-2003)	Post Installation (2006-2009)	Percentage Change
All fatal and serious crashes	4.9	1.8	-63%
All crashes	32.9	54.0	+64%

11.4 Black-Spot Improvement Program in Thailand

11.4.1 Introduction

Road accidents have long been one of the major problems causing economic and social losses in Thailand. Over the past ten years, reducing the road toll has been one of the top priorities by the Thai government. A number of policies and strategies have been proposed toward road safety improvements. The Department of Highways (DOH), under the Ministry of Transport, has adopted the black-spot improvement program, which is an engineering-based method which focuses on improving road conditions that might contribute to the occurrence of accidents.

Over the past few years, problems at many locations have been addressed and the results, in terms of a reduction in accident are starting to become apparent. Based on the accident records of the DOH, the number of accidents, including deaths and injuries has been decreasing since 2004 (see Figure 11.9). Other measures such as enforcement and education are also considered to have contributed to the reduction in accidents.

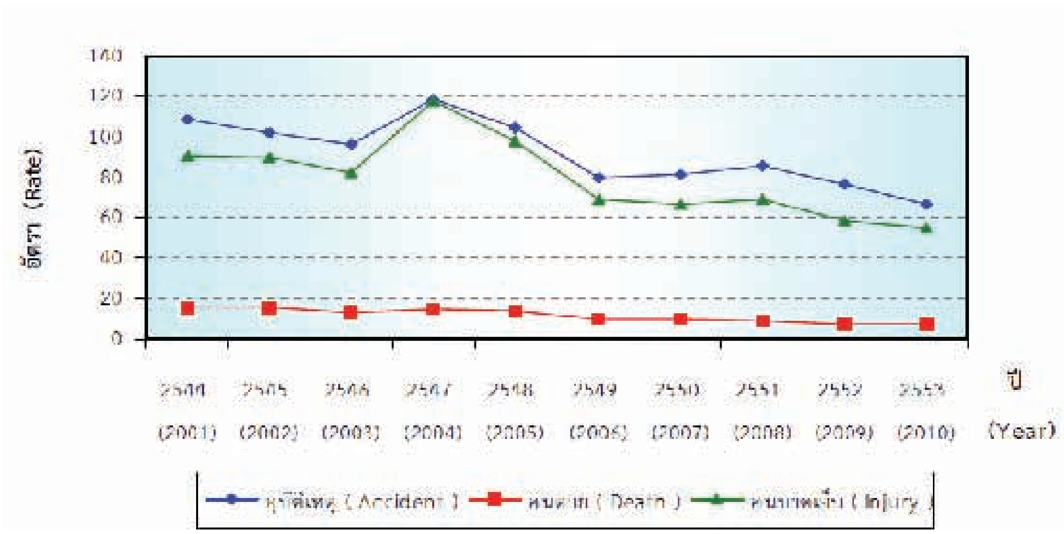


Figure 11.9: Accident rate per billion-vehicle-km in Thailand

11.4.2 Black-spot Sites

A black spot is a location where a large number of accidents occur within a defined period of time. Some countries may define different frequencies and time periods but the common assumption is that there might be some road environmental or geometric issues contributing to the significant number of accidents at a location. An international comparison of black-spot identification criteria is provided in Table 11.3.

Table 11.3: International Comparison of Black-Spot Identification Criteria

Country	Road Section Length	Frequency
Australia	fairly short	at least 3 casualty crashes in 5 years
England	300 meters	12 crashes in 3 years
Germany	300 meters	8 crashes in 3 years
Norway	100 meters	4 crashes in 3 years
Portugal	200 meters	5 crashes in 3 years
Thailand	various	at least 3 crashes in 1 year

The issue with black-spot identification is not the variation of the establishment of the criteria but the methods used to screen and group black-spots on the road. The conventional method used to identify black-spots relies on fixed lengths of road sections, where the total length is divided into 300, 500 and 1,000 metre long road sections. The number of accidents occurring within each road section is then calculated and compared to the black-spot criteria. However, the method seems inappropriate because the section length is fixed and accidents within each section may not be related to each other. Moreover, the method tends to overlook hazardous locations; section lengths should be long enough to cover all continuous accidents that may be related to each other.

The sequential pacing data analysis technique is then used to simulate a manual method where road inspectors travel along a highway and inspect all accident records. As illustrated in Figure 11.10, accidents within 100 metres of a location are grouped together as a black-spot location, whilst any accident located farther than 100 metres from that location are assigned another black-spot location ID. The Sequential data analysis for black-spot identification is shown in Figure 11.11.

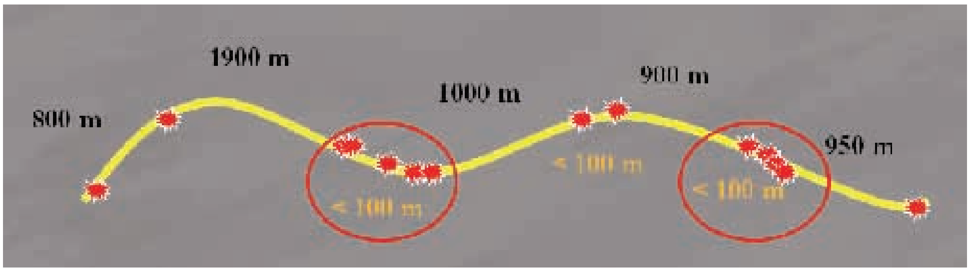


Figure 11.10: Algorithm for black-spot identification

Based on accident data from 2006 and 2008, the number of identified black-spot locations is listed in Table 11.4 according to different frequencies. Not only did this technique allow highway engineers to identify black-spot locations faster but also it provided more opportunity to address the possible causes of repeated accidents.

Table 11.4: Number of Black-Spot Locations

Accident Frequency (number per year for any black-spot location)	Number of Identified Black-Spot Locations (2006 accident data)	Number of Identified Black Spot Locations (2008 accident data)
2	1,608	1,519
3	748	698
4	459	448
5	316	325
6	241	252
More than 7	189	196

In late 2008, the list of 748 black spot locations based on the 2006 accident data was distributed to 15 regional offices around the country and local engineers were asked to investigate causes and propose solutions, including budgets, to the central office. The Bureau of Highway Safety, a unit under DOH, gathered the information submitted by the regional offices and prioritized black-spot sites based on accident frequency, severity, total accident cost and the proposed budget to address the issues. In 2009, the government provided a grant of approximately US$12.5 million to improve the first 93 black-spot sites; another US$20 million was provided for another 147 locations in 2010.

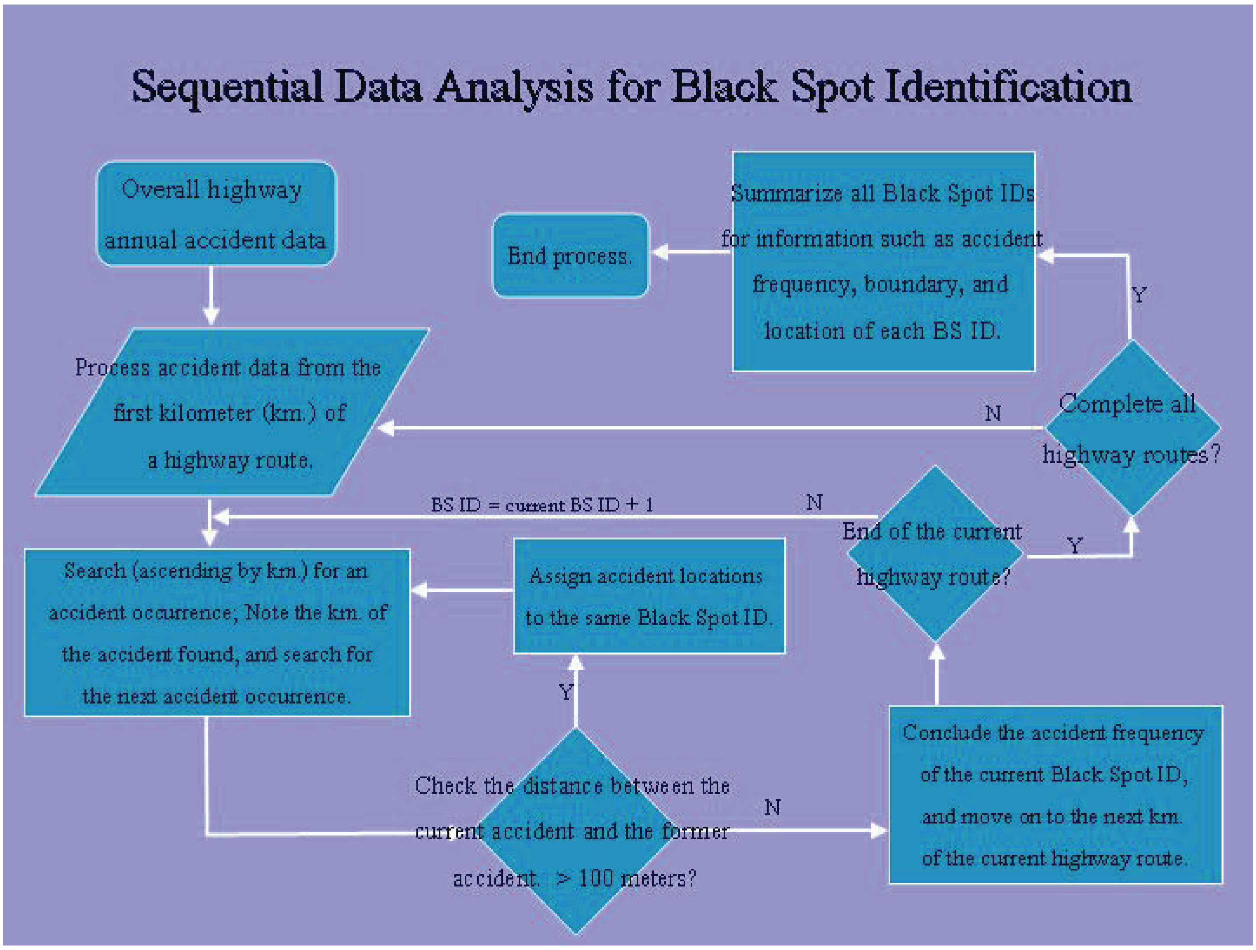


Figure 11.11: Sequential data analysis for black-spot identification

11.4.3 Outcomes and Evaluations

Black spot improvements involved enhancing geometric designs, pavement rehabilitation and safety upgrades. After completing the improvement programs, five locations were chosen for case studies to evaluate the effectiveness of the measures designed particularly for those sites. The summary of these locations, the cost of the improvements, and the number of accidents before and after the improvements are shown in Table 11.5. The number of accidents were compared for the month after the completion of the improvement and the same month the previous year before the improvements. The benefits calculated based on the number of lives saved multiplied by the severity costs. The cost is the investment cost of the improvement.

Table 11.5: Summary of Benefit-Cost Analysis

Location	Length (km)	AADT (veh/day)	Cost (US$)	No. of Accidents	B/C
SR 224	0.775	2,486	$307,200	3 (3 inj, 3 sinj)	none
SR 1020	1.551	4,789	$466,600	3 (3 inj, 1 sinj)	none
SR 3348	0.530	7,661	$241,900	4 (2 inj, 1 sinj)	none
SR 3032	0.745	8,987	$331,640	3 (2 inj, 1 sinj)	none
SR 402	0.325	38,421	$483,640	8 (12 inj, 2 fat)	none

Note: inj = injury; sinj = serious injury, fat = fatality.

Details of each site, the possible cause of the accidents and the improvements made, are now presented.

State Route 224 (Burirum) from km 10+650 to km 11+425 (*Figure 11.12*)

Possible Causes of Accidents	Measures Taken
▪ High number of farm vehicles ▪ No street lighting ▪ Location of driveways poor	▪ Lanes added and shoulder widened ▪ Street lighting installed ▪ New road markings provided


Figure 11.12: Road conditions on SR224 before (left) and after (right) improvement

State Route 1020 (Chiang Rai) from km. 27+849 to km 29+400 (*Figure 11.13*)

Possible Causes of Accidents	Measures Taken
▪ High number of speeding vehicles ▪ Downhill grade combined with sharp curve without superelevation ▪ No street lighting	▪ Shoulder widened ▪ Street lighting installed ▪ New delineator installed ▪ New road markings ▪ Fixed guardrails


Figure 11.13: Road conditions on SR1020 before (left) and after (right) improvement

State Route 3348 (Chantaburi) from km. 7+722 to km 8+252 (*Figure 11.14*)

Possible Causes of Accidents	Measures Taken
▪ Unsignalized intersection ▪ Lane narrow and many high-speed vehicles ▪ No street lightings installed	▪ Lane added with median ▪ Intersection improvement ▪ Traffic lights installed ▪ Street lighting installed ▪ New road markings and signs

Figure 11.14: Road conditions on SR3348 before (left) and after (right) improvement

State Route 3032 (Singburi) from km. 4+355 to km 5+000 (Figure 11.15)

Possible Causes of Accidents	Measures Taken
▪ Sharp curve ▪ Improper road access at curve ▪ Poor sight distance	▪ Highway widened ▪ Intersection upgraded ▪ New concrete barrier installed ▪ More street lighting installed ▪ New road markings and signs

Figure 11.15: Road conditions on SR3032 before (left) and after (right) improvement

State Route 402 (Phuket) from km. 35+175 to km 35+500 (*Figure 11.16*)

Possible Causes of Accidents	Measures Taken
▪ High speed in curve ▪ Slippery road surface	▪ Improved curve radius by widening and upgrading geometry ▪ Road surface rehabilitated ▪ Sight-distance increased ▪ More warning signs added

Figure 11.16: Road conditions on SR402 before (left) and after (right) improvement

11.4.4 Conclusions

The sequential pacing data analysis technique simulates a manual method based on a condition that nearby accidents within 100 metres shall be grouped together as a black-spot location. Compared with the conventional method, the sequential pacing data analysis technique is more accurate in identifying black-spots, regardless of the black-spot section length. This useful tool allows highway engineers to identify high-risk road sections and prioritize their budgets to taget the locations most in need of treatment.

The discussion and collaboration between local engineers and the program coordinators from the Bureau of Highway Safety regarding the possible causes of accidents, and the proposed solutions at each location, made the black-spot improvement program more effective. Previously, the coordinators received only the plans for safety improvements submitted by local engineers and the coordinators had to assume that they have prioritized their plan which may or may not have identified the most high-risk locations. With the list of black-spot sites in hand, the program coordinators can make better decisions in terms of budget planning and prioritization. After the improvement works were carried out, the evaluation of the improvements was performed. The decrease in the number of accidents demonstrated that the program is highly effective and that the DOH should continue to upgrade the remaining black-spot locations.

11.5 Prioritized Implementation of Traffic Safety Measures at Accident Black-spots in Japan

11.5.1 Introduction

Traffic accidents on national highways and prefectural highways in Japan tend to occur at particular locations. In July 2003, the National Police Agency and the Ministry of Land, Infrastructure, Transport and Tourism cooperatively designated intersections and uninterrupted road sections where the rate of fatal and injury accidents was high as 'accident black-spots'.

The locations of accident black-spots were selected using the criteria presented in Table 11.6. They were selected based on accident data from 1996 to 1999. Using these criteria, a total of 3,956 accident black-spots were identified throughout Japan where measures would be taken during Phase 1 of the project between 2003 and 2007.

Examples of traffic safety measures undertaken at accident black-spots included road improvements, the installation of safety equipment, and the installing of improved signals. Where appropriate (e.g. on truck roads) the improvements were implemented in cooperation with prefectural public safety commissions and road administrators.

Table 11.6: Criteria Used to Select Accident Black-spot Locations

Condition category	Criteria
A	Locations where one fatal accident might recur every 10 years: ▪ number of fatal and injury accidents: 28 accidents or more every 4 years ▪ converted to number of fatalities: 0.4 accidents or more every 4 years
B	Locations where accident rate at the location is at least 5 times the average accident rate on trunk roads: ▪ uninterrupted road sections: 325 accidents or more per 100 million vehicle-km ▪ intersections: 500 accidents or more per 100 million vehicle-km
C	▪ Locations where it is recognized that traffic accidents may occur frequently, and urgent and intensive measures are necessary ▪ Locations which meet criteria A and B

Specific examples of road improvements included the installation, or lengthening, of right-turning lanes to prevent right-turning-vehicles from blocking vehicles travelling straight ahead, and the installation of channel markings to clarify the driving lanes inside intersections.

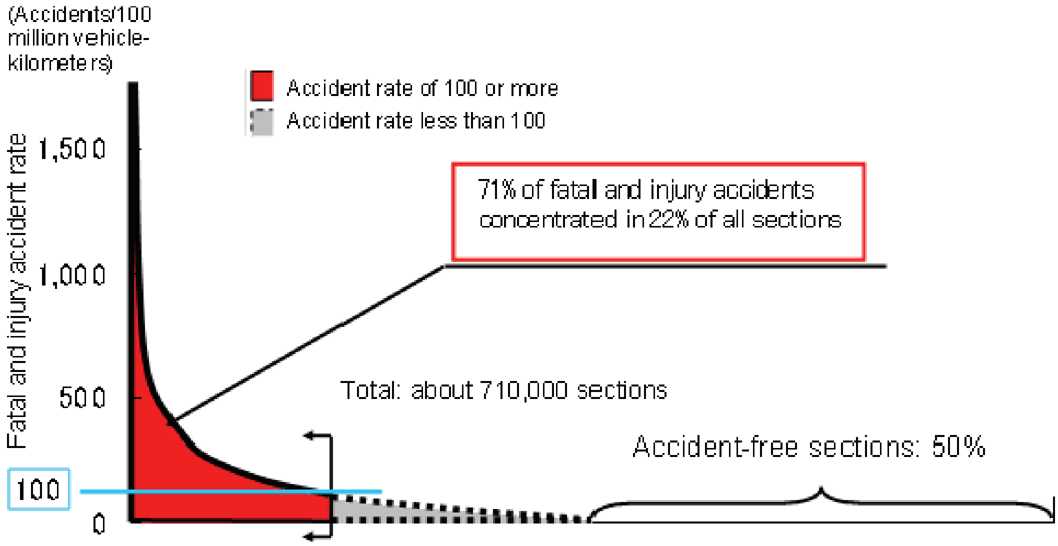
Specific examples of safety facilities installed included:

- centre medians, which prevent vehicles from deviating into on-coming lanes, thus avoiding head-on collisions
- guard fences, which prevent passengers and third parties being injured by vehicles leaving the road
- alerting signboards, which inform drivers of hazardous road surfaces (freezing, etc.).

11.5.2 Background

A database has been developed that lists both the state of occurrence of fatal and injury accidents and the traffic volumes at the locations where the accidents occurred on both national and prefectural highways. In establishing this database, the road network was divided into 710,000 sections and accident data collected between 2003 and 2006 was used. The fatal and injury accident rate in each section was calculated by dividing the number of fatal and injury accidents by the number of vehicle-km in the section. The results, shown in Figure 11.17, show that 71% of the fatal and injury accidents occurred on 22% of the network.

Because traffic accidents on trunk roads tend to occur at particular locations, the selection of the locations where measures should be taken is vital if they are going to be effective in reducing deaths and injuries.



※Prepared based on average traffic accident data for four years (2003 to 2006) on approximately 180,000km of national highways and prefectural highways throughout Japan.

Figure 11.17: Fatal and injury accident rates on national and prefectural highways throughout Japan

11.5.3 Intended Outcome

The intended outcome was a 30% reduction in the number of fatal and injury accidents at accident black-spots.

11.5.4 Description

As example of a specific treatment is the Mishimabashi Intersection on National Road No. 3 in Fukuoka city, located in the west of Japan. Approximately 400 fatal and injury accidents per 100 million vehicle-km had occurred at this intersection, demanding urgent measures. In addition, and as shown in Figure 11.18, there were rear-end collisions. An analysis of their causes of the rear-end accidents revealed that the right-turn lane was too short, with cars forced to remain in the through lane. Other accidents were related to vehicles changing lanes. As a result, the right-turn lane was extended by 50 metres by moving it to the opposite side of the piers of a viaduct. This measure led to a sharp reduction in the number of rear-end collisions and lane-changing accidents.

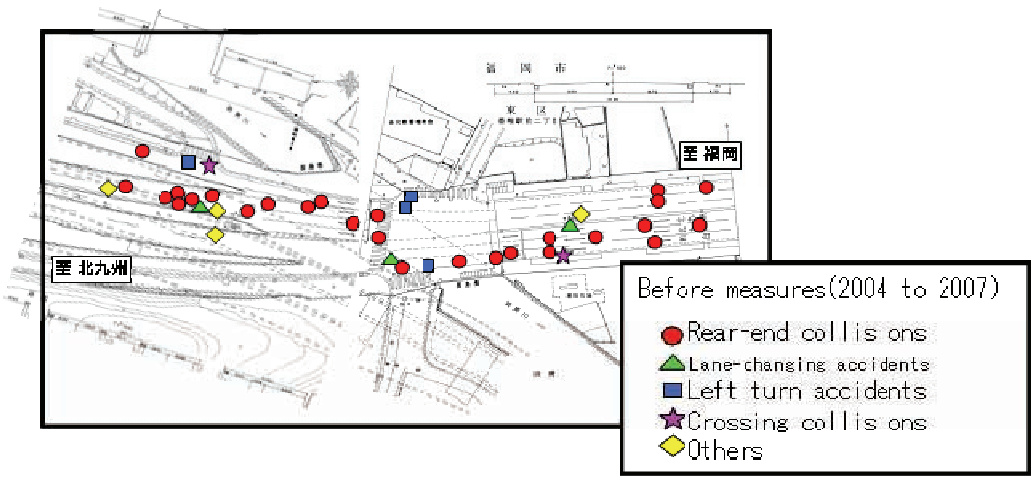


Figure 11.18: Map of accidents around the Mishimabashi Intersection (before treatment)

A view of the Mishimabashi Intersection before and after treatment is shown in Figure 11.19.

Figure 11.19: Mishimabashi Intersection before and after treatment

11.5.5 Results

The effectiveness of the measures was evaluated from two perspectives:

- Have the measures been properly implemented?
- Did the traffic safety measures reduce the number of fatal and injury accidents?

The evaluation of the state of the implementation of measures was conducted at locations where measures had been successfully implemented by 2007. This was because it is assumed that the effectiveness of measures may not be apparent at locations where the implementation of the measures had not been completed. The reduction in fatal and injury accidents was then evaluated by assessing the difference between the average number of accidents before and after the implementation of the measures.

Implementation of measures

The status of the implementation of the measures is shown in Table 11.7. It can be seen that work to implement the measures had commenced at about 97% of the accident black-spot sites throughout Japan during the implement period. It can also be seen that the implementation of the measures had been completed at about 83% of the sites. Although work had not commenced at 3% of the sites and had not been completed at 17% of the sites, overall it can be concluded that the measures had been properly implemented during the implementation period.

Table 11.7: Status of Implementation of Measures

	Number of locations where measures had commenced	Number of locations where measures had been completed
During implementation period (2003-2007)	3,837 (97%*)	3,271 (83%)
After implementation period (2008-2009)	86 (2%)	421 (11%)
Total	3,923 (99%)	3,692 (93%)

* Ratio to total number of accident black-spots (3,956).

Reduction in fatal and injury accidents

The reduction in fatal and injury accidents at 3,271 black-spot sites was evaluated as follows:

a) Sum the total number of fatal and injury accidents used to set the targets (annual average from 1996 to 1999) at each location where the measures were implemented.

b) Calculate the rate of change of the number of fatal and injury accidents nationwide by comparing the data before the measures were implemented (annual average from 1996 to 1999) and after the measures were implemented (annual average from 2004 to 2008). Multiply this by (a) (assuming that the trend in the change in the number of accidents changes throughout Japan was identical).

c) Calculate the annual average number of fatal and injury accidents at each location from the year after the successful implementation of the measures.

d) Compare (b) with (c).

It was concluded that the rate of reduction in the number of fatal and injury accidents at the accident black-spot locations where measures had been implemented was 31% (see Figure 11.20). In other words, the implementation of the measures resulted in the target reduction in fatal and injury accidents of 30% being achieved.

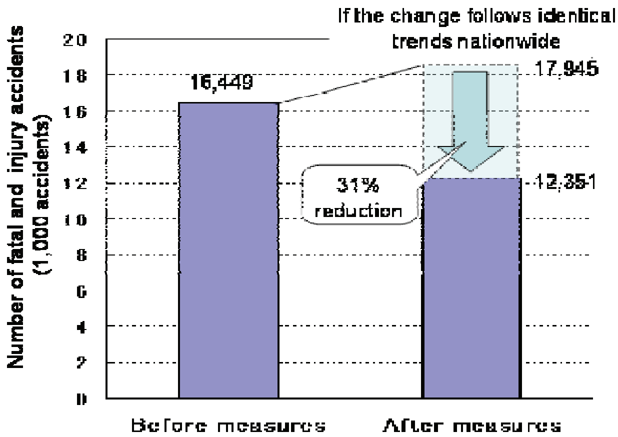


Figure 11.20: Number of fatal and injury accidents at locations where measures were successfully implemented

11.5.6 Future Implementation

Although the measures implemented at accident black-spot locations resulted in a 30% reduction in the number of fatal and injury accidents, it was necessary to continue to implement measures at accident black-spot locations on trunk roads, where two-thirds of traffic accident fatalities occur.

In 2008, 3,396 locations were designated as ‘second phase accident black-spots’, and traffic safety measures are being continually implemented to achieve the target of reducing the number of accidents by 30%.

In addition, the *Accident Zero Plan (Priority Strategy for Elimination of High Accident Potential Sections)* will be implemented in cooperation with relevant organizations. In this program, specified sections having a high risk of traffic accidents, and where concentrated measures need to be implemented (high accident potential sections) ,will be selected by analysing accident data and, in cooperation with residents, priority projects implemented. Another aim of this program is to improve public awareness of ‘high accident potential sections’ and demonstrate the effectiveness of the traffic safety measures implemented.

Another outcome is that road administrators can select and implement measures relevant to the causes of accidents at a particular location using the data collected during the implementation of the program.

Reference

Ministry of Land, Infrastructure, Transport and Tourism 2011, *Policy review result in FY2010 (evaluation document), The safety policy of the road traffic*, March.

12 NON-ENGINEERING ISSUES

12.1 Road Safety Governance in Victoria

12.1.1 Introduction

Since 1995 Victoria has had a management and co-ordination framework that has supported the successful partnership approach to improving road safety and reducing the impact of road trauma.

12.1.2 Background

Victoria's road safety achievements have been delivered through strong and co-ordinated partnerships between government, its agencies (VicRoads, Transport Accident Commission, Victoria Police and Department of Justice) and the wider community. The management and governance structure for the *arrive alive 2008-2017* road safety strategy is shown in Figure 12.1.

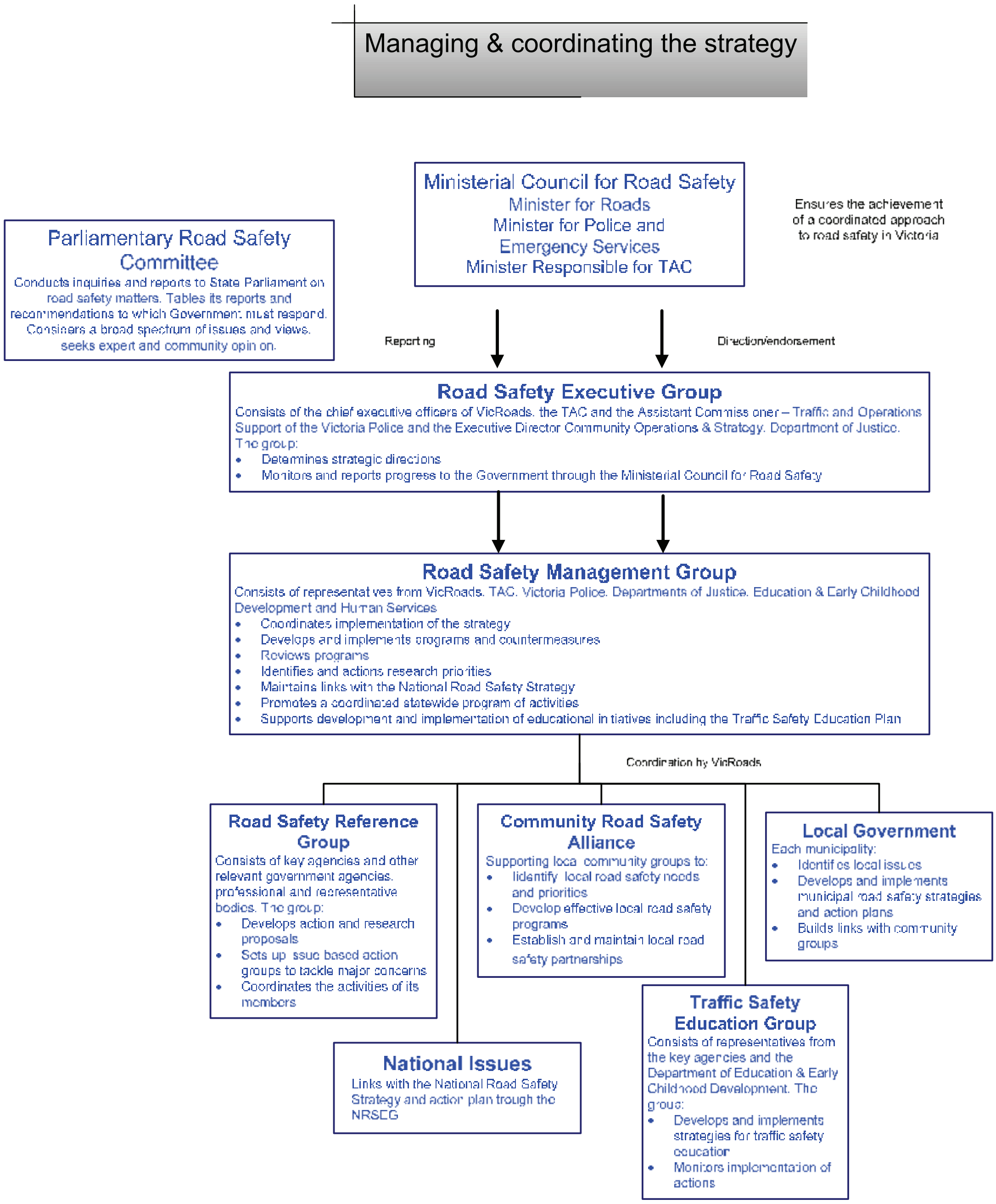


Figure 12.1: Road safety governance in Victoria

12.1.3 Agency Roles and Responsibilities

The roles and responsibilities of road safety agencies in Victoria are summarised in Table 12.1.

Table 12.1: Roles and Responsibilities of Road Safety Agencies in Victoria

Agency	Role and Responsibility
VicRoads	▪ road infrastructure, network operation and speed limits ▪ registration and licensing ▪ Road Safety Act and regulations (advice to Minister for Roads) ▪ vehicle standards ▪ behavioural and educational program development
Transport Accident Commission	▪ marketing and promotion, new technologies, enforcement support, infrastructure support
Victoria Police	▪ enforcement and public education.
Department of Justice	▪ management of enforcement technology ▪ justice policy

The Ministerial Council for Road Safety[17] is responsible for ensuring the achievement of a co-ordinated approach to road safety. It comprises the Minister for Roads, the Minister for Police and Emergency Services and the Minister responsible for the Transport Accident Commission. The Victorian management and co-ordination framework is highly regarded both nationally and internationally.

According to the US Department of Transportation (2005):

> *"The current Victorian strategy is a model in this regard (reference to research based initiatives and accountabilities for implementation).*
>
> *There is clear political leadership. Senior politicians comprise the 'Ministerial Road Safety Council'. These are the Minister for Transport, the Minister for Police and Emergency Services and the Minister for the Transport Accident Commission. All three are senior politicians and they have considerable collective power within government circles."*

The Ministerial Council for Road Safety has been a key mechanism to ensure a co-ordinated approach to road safety. It is considered that the high level political leadership provided by the Ministerial Council has benefited the co-ordinated development and implementation of road safety strategies and initiatives.

Reporting to the Ministerial Council for Road Safety is the Road Safety Executive Group. It comprises agency Chief Executives, Department heads and the Deputy Commissioner for Police. This group is effectively responsible for determining strategic directions and monitoring progress on the implementation of initiatives to support the aims and targets of the road safety strategy.

Supporting the Road Safety Executive Group is the Road Safety Management Group. This group co-ordinates implementation of the strategy, develops and implements programs and countermeasures, reviews programs, and links with other professional organisations, community groups and local government.

The importance of a co-ordinated approach is the ability to commit to on-going actions and resourcing to achieve the strategy targets. The most effective use of scarce resources is agreed between agency heads and ultimately the Government.

The Road Safety Reference Group, The Road Safety Alliance and Local Government represent a wide group of organisations with an interest in road safety that provide advice, assistance in

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[17] Following a recent change in Government, the role of the Ministerial Council for Road Safety has been assumed by the Transport Cabinet Committee.

delivering programs and act as a sounding board for the broader community on road safety issues and emerging trends.

The accountabilities of the agencies has also necessitated strong links with research organisations such as the Monash University Accident Research Centre (MUARC) and ARRB Group (ARRB). In the case of MUARC, a significant financial contribution is made to ensure that an agreed and co-ordinated research program is conducted annually on emerging issues and that research is targeted at the key initiatives contained within the road safety strategy.

A further key component of road safety in Victoria is the Parliament of Victoria Road Safety Committee, which comprises politicians from both the Government and the Opposition. While the Committee is advisory in nature, it conducts inquiries on road safety issues by seeking expert and community opinion. Submissions include those from the road safety agencies. The Committee tables a report to Parliament that contains recommendations for improving safety. The Government must respond to these recommendations.

12.1.4 Results and Evidence

Since the first *arrive alive! 2002-2007* road safety strategy commenced, Victoria's road toll has been reduced from 444 in 2001 to 288 at the end of 2010, a reduction of 35%.

Reference

US Department of Transportation 2005, *Halving deaths from road traffic crashes*, Federal Highway Administration, October.

12.2 Austroads Review of Crash Databases

12.2.1 Introduction

Crash databases are an essential tool in analysing crash risk. Databases allow the identification of high-crash locations and provide information on crash causation, allowing these crashes to be effectively targeted. The information contained in crash databases also allows analysis of trends in crashes; as such, they assist greatly in strategic safety-related decisions.

Each Australasian jurisdiction has developed its own crash database system, and the analysis tools available for each vary. In order to add value to this data and better inform decision-makers, additional tools should be available for use in some or all of these databases. Austroads, the association of Australian and New Zealand road authorities, instigated a project to identify good practice in database design, including features that may be of high interest to Australasian jurisdictions. The intention of the project was to collect information on the features of each database system, rather than the design of the system itself. In addition, as the focus was on useful tools for the assessment of crash risk, including those at specific crash locations, databases that aggregate information from other crash databases were generally not included.

The method used to collect information included internet, library and database searches to locate all relevant literature, a survey of Australasian database managers, and a survey of overseas database managers. Each of the Australasian databases was assessed, and in several cases live demonstrations provided. Contact was also made with a number of international experts, including those involved in research on crash databases, database managers and commercial providers of databases. Information was obtained on 11 different database systems, and live demonstrations provided on two of these.

12.2.2 Results

A full report for this project is available in Austroads (2010). The following provides a summary of some of the useful features available for crash systems based on the review of literature, and contact with international and Australasian jurisdictions. Note that it is not to be expected that any one crash system should possess all of these features. However, it does indicate the range of options that jurisdictions should be considering when developing or updating their own systems.

Some of the key useful features include the following.

- Data entry:
  - in-vehicle computers or hand-held PDA for the reporting of crashes by Police, with direct links to the crash database system
  - GIS linkage to allow accurate location of crashes as well as links with external data sources to validate data fields collected by the Police as well as the provision of additional data fields not already available to Police, e.g. driver and vehicle information
  - increased take-up of GPS in Australia and New Zealand; accurate use of GPS would lead to more accurate location of crashes, although it was noted that errors can occur when coordinates are recorded manually, and that an electronic link was seen as ideal
  - in-built quality control algorithms and logic checks
  - tests to ensure completeness of data
  - checks against records at the same crash location to compare data (e.g. road features)
  - the ability to submit details on non-reported crashes either directly to the database or on-line (these can be flagged as non-Police reported)
  - higher priority given to data entry of more severe crashes.

- Data items included in the database:
  - contributory factors to crashes (level of confidence has been used overseas given the subjective nature of this data field)
  - links to hospital data to provide information on injury outcomes, and also information on Police reporting rates; an example from the Swedish STRADA system is shown in Figure 12.2

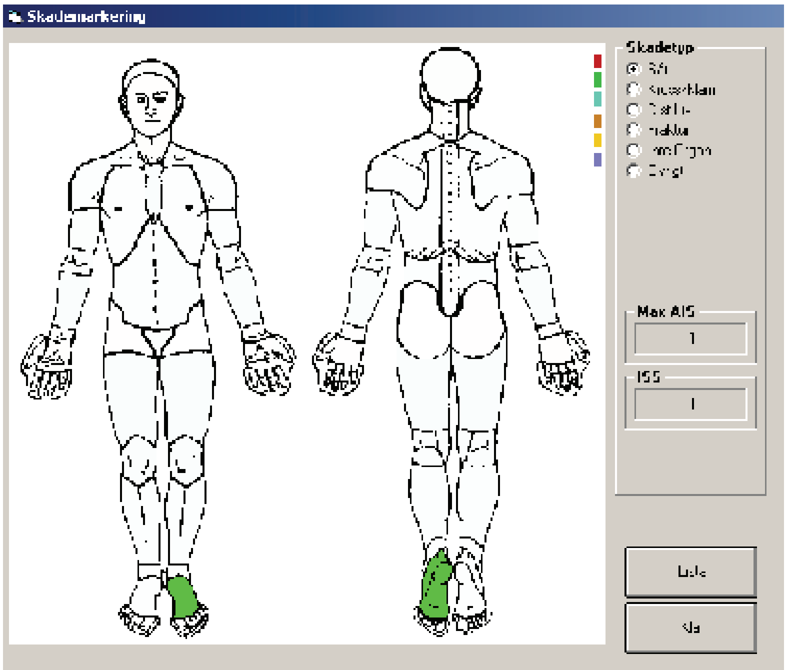


Figure 12.2: Link to injury data in Swedish system

  - information on traffic density at the time of the crash
  - information on what pedestrians and motorists were doing at the time of the crash (e.g. trip purpose)
  - additional information on heavy vehicles
  - the ability to add new data fields without needing to issue a contract to redevelop the database.

- Database navigation:
  - ability to select individual crashes by clicking on crash from a collision map
  - pre-defined queries
  - user-defined queries
  - drop-down menus
  - ability to select any combination of variables easily.

- Analysis of crashes – sites of interest:
  - ranked sites based on crash rates, crash numbers, crash costs or crash commonality
  - site summaries
  - route assessments; an example of a route assessment from Tasmania is shown in Figure 12.3

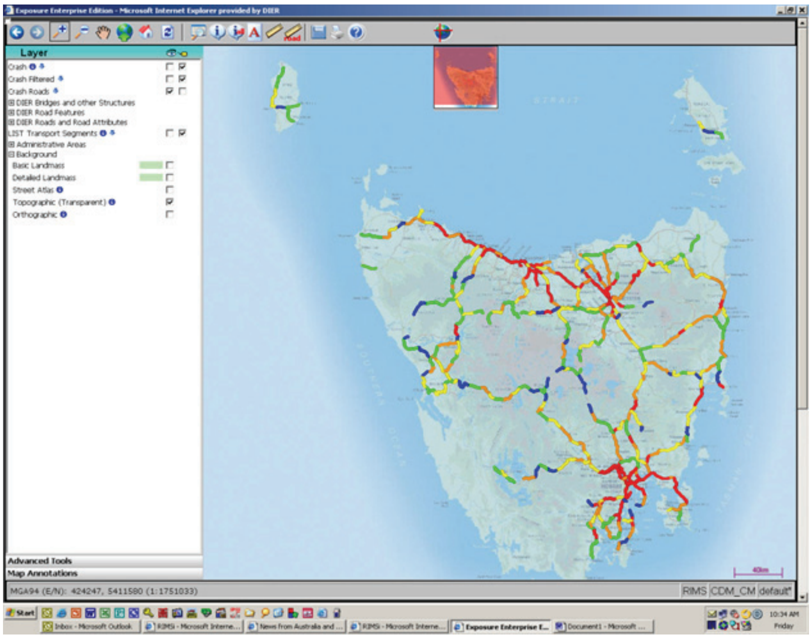


Figure 12.3: Tasmanian route assessment

- crash density maps
- comparison of sites against norms for the rest of the database or other similar sites or areas
- alarm reports
- the ability to produce reports for corporate applications (including information summaries for local government)
- factor matrix or 'stick diagrams'
- automatically generated collision diagrams (with correct orientation); an example from New Zealand is shown in Figure 12.4
- access to scanned reports (particularly a sketch of the crash scene)

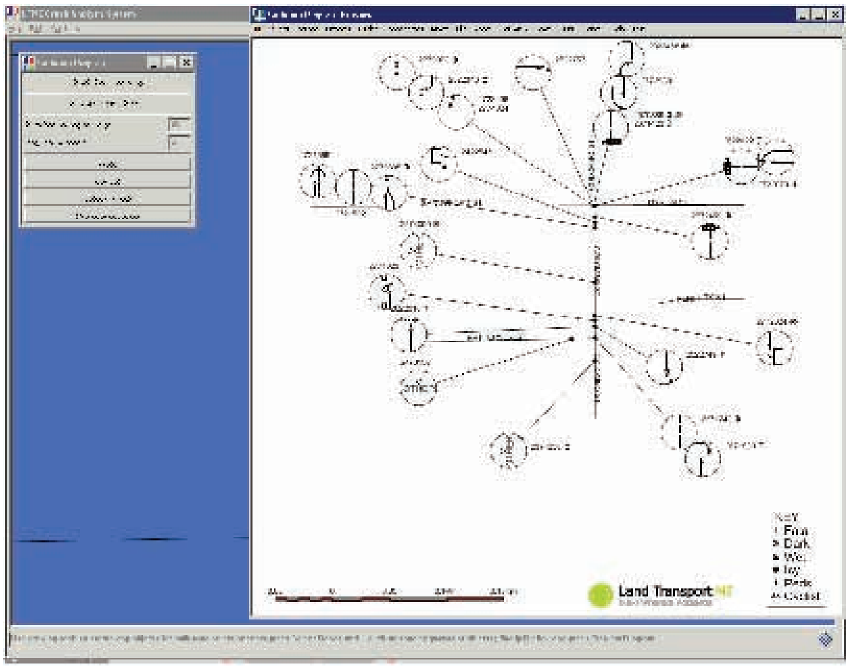


Figure 12.4: NZ collision diagram

  - ability to select crash details by selecting the crash (or group of crashes) from a map
  - ability to provide relevant data on one page or in one document (e.g. raw crash data, collision diagram, factor matrix)
  - links to traffic volume data
  - links to aerial photographs, photos or video of the crash location.

- Analysis of crashes – policy level:
  - pre-defined reports
  - user-generated reports
  - the ability to easily export data to third party applications (e.g. SAS) for more detailed statistical analysis
  - cross tabulations.

- Mapping ability:
  - ability to confirm crash location at data entry stage
  - crash selection on a geographic basis
  - presentation of crash information, including thematic and pie charts
  - ability to link with other GIS sources
  - ability to recognise the current map scale, and provide relevant information accordingly.

- Integration with other data:
  - citation and conviction data
  - licence information and driver history
  - medical records
  - coronial data
  - motor vehicle registration details
  - traffic volumes
  - asset data
  - population and demographic data (e.g. from census)
  - police intelligence data
  - vehicle inspection data
  - aerial photography, topographic maps, street maps, photos, video
  - a simple data export facility to allow easy external integration of data.

- Quality of data:
  - consistency or logic checks for data entry
  - requirement for a training course before the database is used
  - disabling of data fields if conflicting fields are selected
  - warnings of possible errors when making queries
  - details of search criteria included on all outputs
  - ability to determine reporting rates (e.g. through a link with medical data).

- Monitoring sites of interest:
    - some form of site monitoring module allowing assessment of sites or locations where the same treatment has been installed to be assessed before and after treatment installation.

- Dissemination:
    - web-based access
    - open access by approved stakeholders
    - public access version of the database; an example of the VicRoads CrashStats system is shown in Figure 12.5.

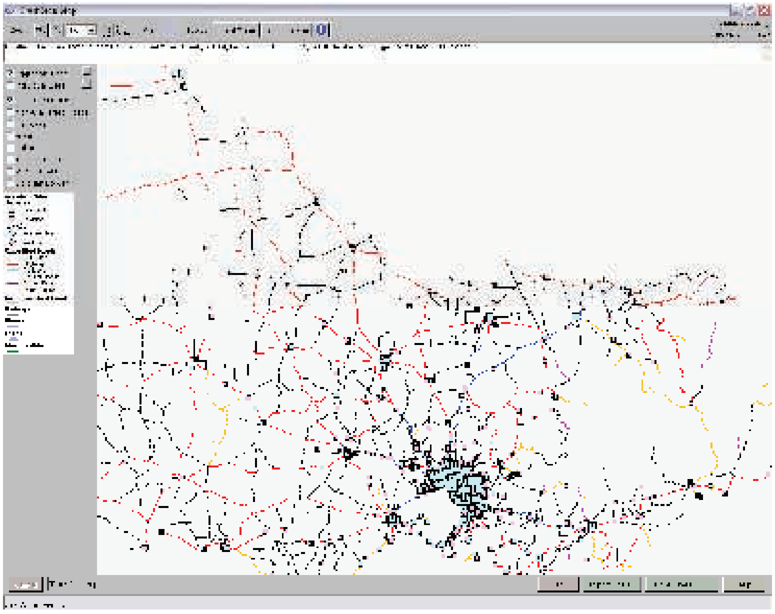


Figure 12.5: Crash mapping from Victoria CrashStats system

12.2.3 Discussion

There was quite a contrast in the functionality of databases used throughout Australia and New Zealand and elsewhere in the world. The functionality did not seem to correlate well with the size of the jurisdiction or the age of the database. In some cases, smaller jurisdictions have very good databases, and older systems appear to have similar or even better features than more modern systems. This may indicate a lack of knowledge within jurisdictions about possible functionality of database systems, something that this research hopes to address.

Given this apparent lack of awareness of what was happening in other jurisdictions and across different countries, there may be advantages in the formation of a 'Regional Crash Database User Group' to help keep track of knowledge and experience in this area. This would be particularly beneficial to those who are just establishing database systems.

All the databases assessed could improve the functionality and provision of information based on one or more of the above features. Given the cost of data collection, and the utility of the information provided, an investment in additional features would appear to be highly cost beneficial.

Although all of the features identified in the results section were seen as being of value, the following features are seen as being particularly useful:

- good linkages with other sources of data (at data entry and analysis stages)
- built-in quality checks

- the provision of contributory factors
- linkages to hospital data
- the ability to select any combination of variables quickly and easily
- all of the analysis tools listed under ‘sites of interest’
- details of the search criteria included on all outputs for quality reasons
- a monitoring module for sites or lengths where safety improvements have been made.
- web-based access
- public access to data.

It is recommended that, when updating or renewing crash databases, these and the other features highlighted be considered. It is also recommended that an informal regional network of database managers be established to facilitate an exchange of knowledge in this area.

Reference

Austroads 2010, Road safety engineering risk assessment – Part 3: review of best practice in road crash database and analysis system design, by B Turner and W Hore-Lacy, Austroads report AP-T148/10, Austroads: Sydney, Australia.

12.3 Deployment of a Highway Accident Information Management System in Thailand

12.3.1 Introduction

Accident statistics are used in the development of road safety strategies and for the implementation of black-spot improvement program in many countries. In Thailand, the Department of Highways (DOH) acquires most of its accident information from Police reports. Local DOH staff periodically visit Police station and enter accident data on the DOH's report form. Each District office then submits the completed forms to the Bureau of Highway Safety (BHS) each month.

However, a number of different items of information required for road safety work are either unavailable or sometimes missing from the Police reports especially the location of accidents. This makes it difficult for the DOH to carry out effective black-spot identification and rectification tasks. In addition, during some special events such the New Year holidays, the Thai government requires road authorities to summarize and report the number of accidents immediately. This creates problems for the local DOH staff since they need to fill in another form online which provides less information but meets the needs of the government in terms of quick response.

The need to develop a better accident data collection system was endorsed through a World Bank project called the *Study of Black Spots Program Evaluation and Road Safety Engineering Capacity Strengthening* in 2008. One of the tasks in the project was to provide guidelines for improving the accident reporting system as well as the accuracy of the information. The BHS adopted the guidelines and commenced implementing them in 2010.

The Highway Accident Information Management System (HAIMS), a new web-based accident reporting system integrated with Geographic Information System (GIS) base map, has been successfully launched. The system allows local DOH staff to fill in a form on-line which is automatically linked to the other form to enable immediate reporting of the accident statistics. The on-line form has been revised so that the accident data is more accurate and sufficient in details for black-spot program evaluation and for other uses. The system also allows both DOH personnel and public users to obtain reports and summary graphics online.

12.3.2 GIS Map for Black-spot Identification

The black-spot identification process involves a technique called Sequential Pacing Data Analysis which requires the position of an accident to be accurately identified. Two accidents occurring within 100 meters of each other will be grouped together. If there is another accident within the next 100 meters, then this location will be identified as a black-spot. If the accident is 130 metres away, then this location is counted as a black-spot. This means that the location of an accident needs to be carefully identified using a tool such as a handheld Global Positioning System (GPS).

The system allows the black-spot locations to be easily viewed on a GIS online map rather than simply on an Excel spreadsheet. Highway and traffic engineers can use this information, plus other embedded information such as traffic volume or surface condition (IRI), to identify the causes of accidents at a particular site. This enhances the effectiveness of the black-spot improvement program. An example of the web-based GIS accident location information, which is available on the BHS website (http://bhs.doh.go.th), is shown in Figure 12.6, whilst an example of an executive summary, which is made available to the public monthly, is shown in Figure 12.7.

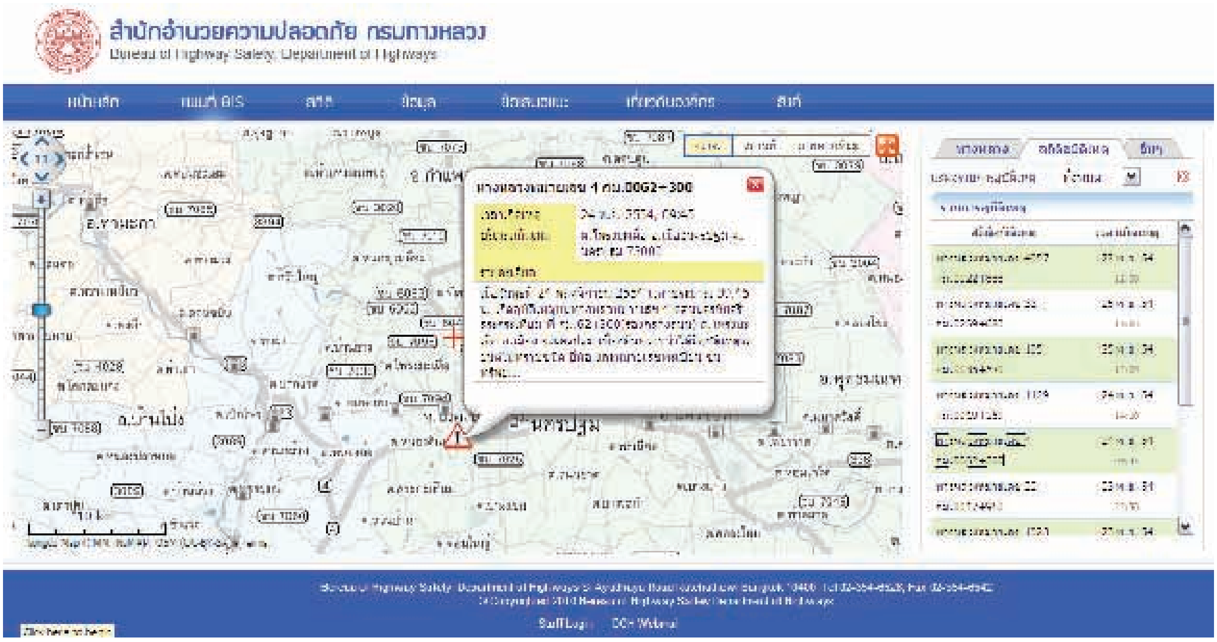


Figure 12.6: Example of web-based GIS accident location information

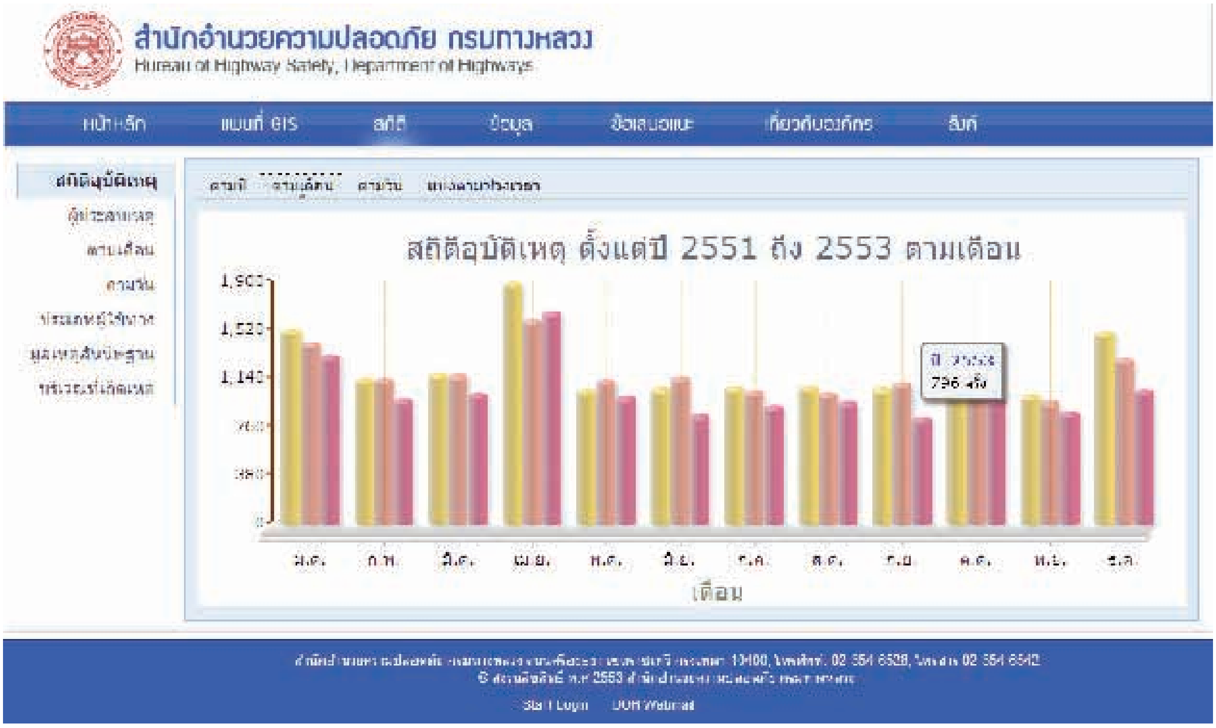


Figure 12.7: Monthly summary of accident data

For DOH personnel, an account with a password is required to access to detailed accident reports through HAIMS (http://haims.doh.go.th) as shown in Figure 12.8. Figure 12.9 shows an example of the locations of black-spots on a GIS map. These black-spots were generated from 2009 accident data. The page can be customized to show different levels of hazard levels and different road geometry.

12.3.3 New Accident Reporting Architecture System

The new DOH highway accident reporting system developed from this information is illustrated in Figure 12.10.

Figure 12.8: Access to HAIMS

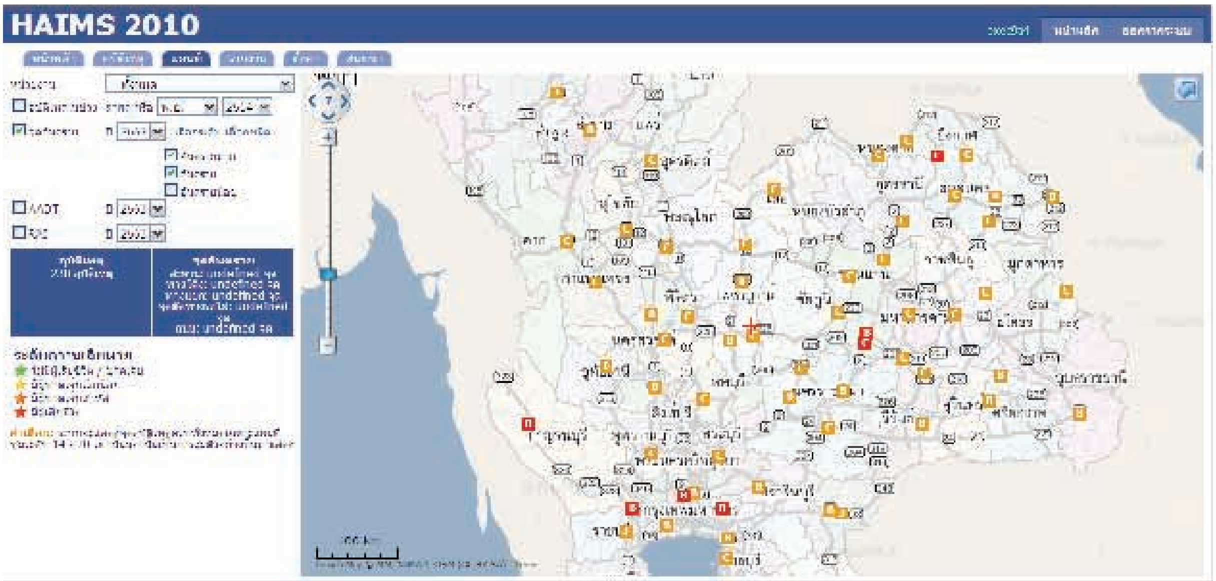


Figure 12.9: Example of the locations of black-spots on a GIS map

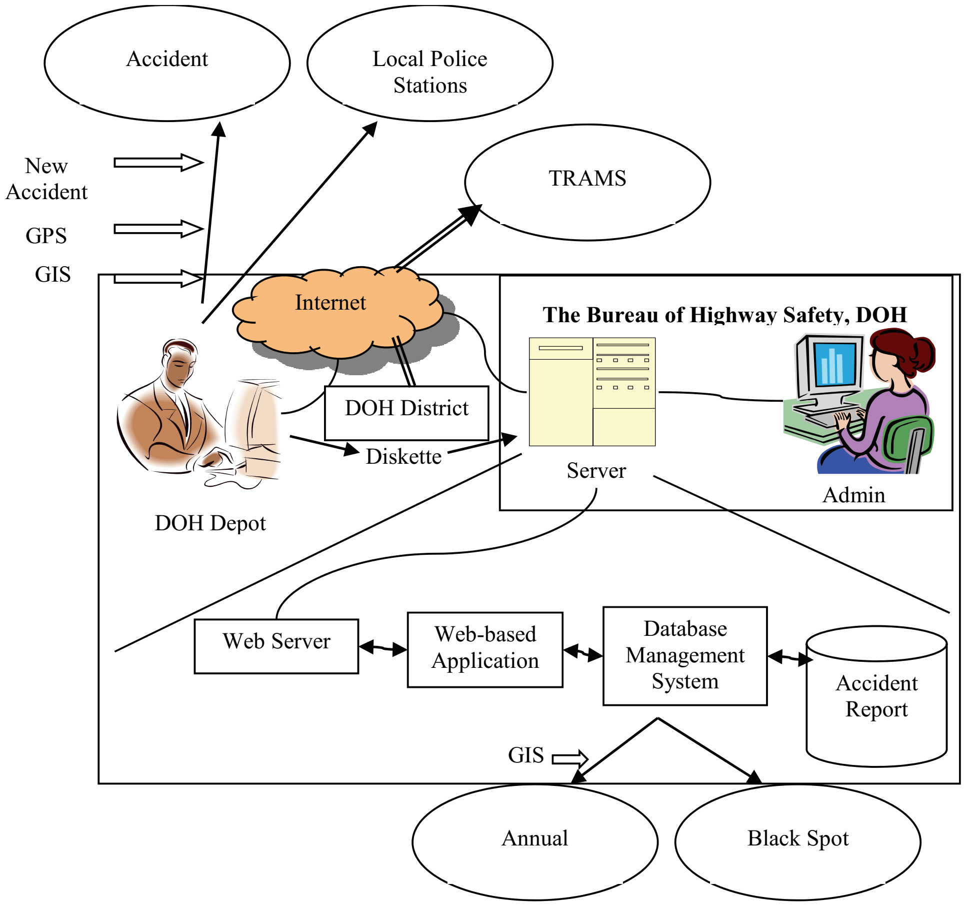


Figure 12.10: New DOH Highway Accident Reporting System

The accident data will be stored in a relational database system to ensure efficient data management and to maintain data integrity. The database will also contain infrastructure and support data in order that it can be verified and to reduce the chance of errors by limiting the variation in the input data, such as road network data, accident type, vehicle type, etc. The information collected using this system will be reviewed by the BHS to ensure the accuracy of the data before it is transferred to the new accident information system.

12.3.4 New Accident Report Form

The new accident report form is not only easy for the local DOH officers to fill in but also it provides more accurate and comprehensive accident data for a highway safety engineer to investigate. When viewing the report, the engineer can also obtain an overview of the location, direction and position of each vehicle involved in an accident. An example of the new accident report form, including details such as road conditions and the environment when accident occurred is shown in Figure 12.11 whilst details of the crash site are shown in Figure 12.12.

12.3.5 Conclusion

The Highway Accident Information Management System (HAIMS) is a new web-based accident reporting system integrated with a GIS base map. It is used by highway safety engineers to easily view details of an accident. It assists engineers and executives to make more informed decisions regarding the current black-spot program. HAIMS is also a centralized database that provides information for future highway planning and road safety monitoring and evaluation such as road safety audit programs and road assessment programs. The features in HAIMS also allow information to be easily shared for further developments in other areas of expertise.

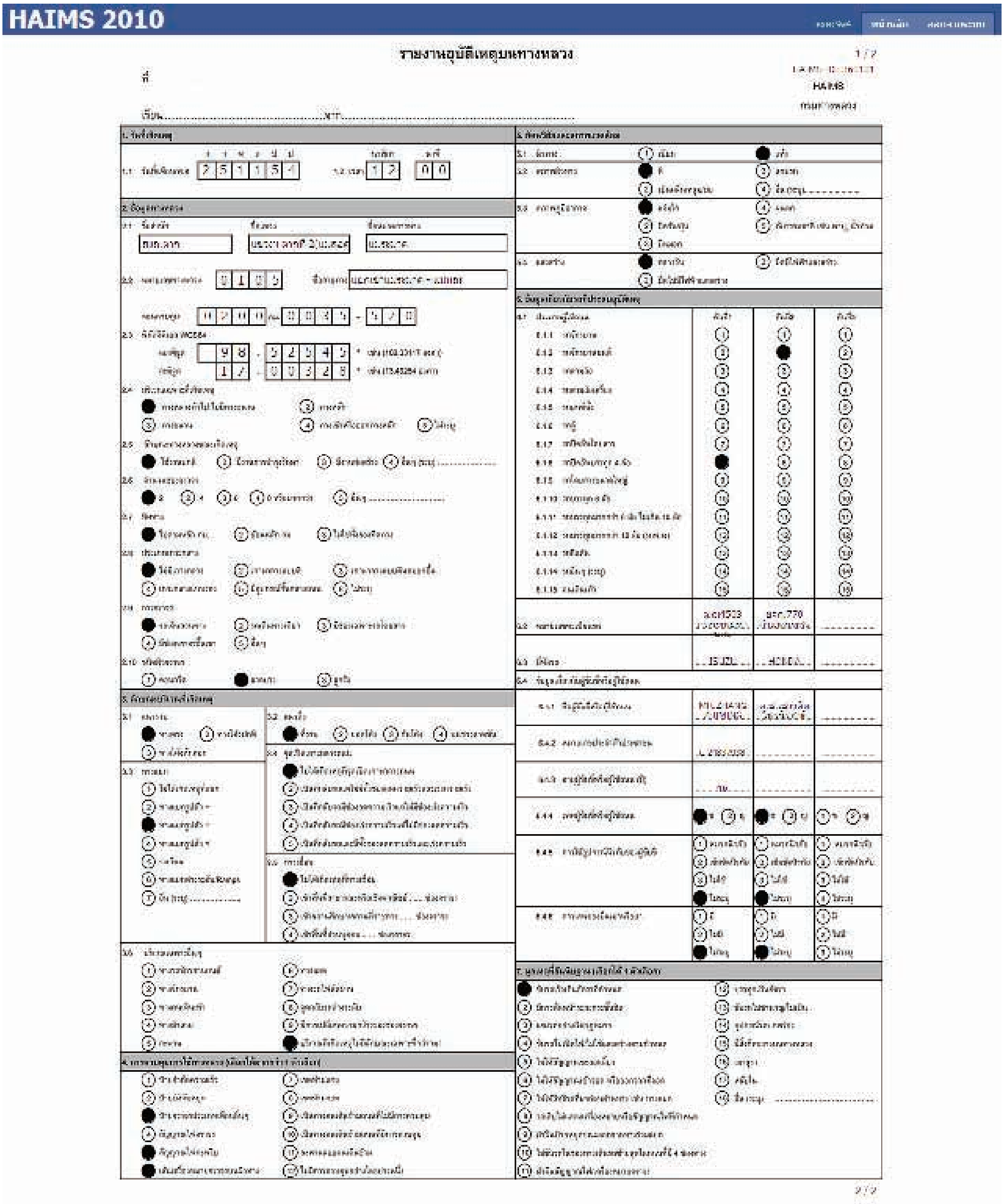


Figure 12.11: Accident information in new report format

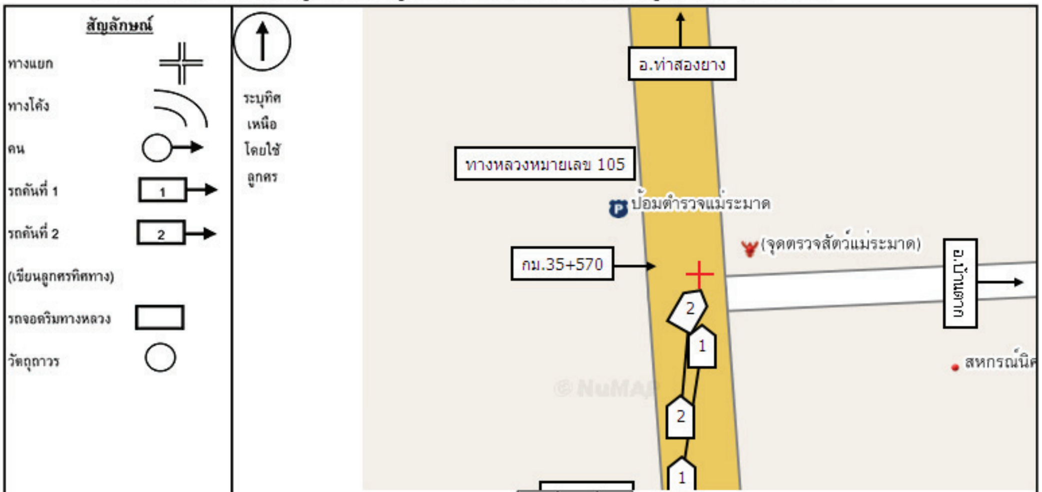
8. ทรัพย์สินของกรมทางหลวงเสียหาย (เลือกได้มากกว่า 1 ตัวเลือก)	
(1) ไม่มีความเสียหาย	(7) สะพาน
(2) ป้ายจราจร/ป้ายทางหลวง	(8) หลัก กม./หลักเขตทาง
(3) ราวกันอันตราย/รั้วริมทาง/หลักกันโค้ง/อุปกรณ์กันชน	(9) เกาะ/อุปกรณ์กั้นกลางถนน
(4) อุปกรณ์ไฟฟ้าและไฟฟ้าแสงสว่าง	(10) ต้นไม้
(5) อุปกรณ์สัญญาณและสัญญาณไฟจราจร	(11) ศาลาทางหลวง
(6) ผิวจราจร/ต้นทาง	(12) อื่นๆ (ระบุ) ....

9. ความเสียหายจากอุบัติเหตุ	ผู้ใหญ่		เด็ก	
	ชาย	หญิง	ชาย	หญิง
ตาย ณ จุดที่เกิดเหตุ	....	....	....	....
ตาย ณ โรงพยาบาล	....	....	1	....
บาดเจ็บสาหัส	....	....	....	....
บาดเจ็บเล็กน้อย	....	....	....	....

ค่าเสียหายของทางราชการ ....36,800 บาท ค่าเสียหายของเอกชน ....บาท

แผนผังสังเขปบริเวณที่เกิดเหตุ

แผนผังสังเขปให้จัดเก็บในรูปแบบของรูปภาพโดยใช้วิธีสแกนหรือถ่ายรูปโดยใช้กล้องดิจิตอล



ประเภทลักษณะการชน (รหัสการชน) | 3 | 0 | 3 |

รายงานเหตุการณ์โดยย่อ

เมื่อวันศุกร์ที่ 25 พ.ย.54 เวลาประมาณ 12.00 น. ได้เกิดอุบัติเหตุโดยรถยนต์บรรทุกขนาดเล็ก ยี่ห้อ ISUZU หมายเลขทะเบียน ฒฌ.4503 กทม. (คันที่1) เดินทางมาจากทางด้าน อ.แม่ระมาด มุ่งหน้าไปทาง อ.ท่าสองยาง และรถจักยานยนต์ ยี่ห้อ HONDA หมายเลขทะเบียน ขจก.770 กำแพงเพชร (คันที่2)เดินทางมาจากทางด้าน อ.แม่ระมาด มุ่งหน้าไปทาง อ.ท่าสองยาง รถคันที่ 1 และคันที่2 ได้เดินทางมาตามทางหลวงหมายเลข 105 ตอน แยกเข้าแม่ระมาด-แม่หละ มาถึงบริเวณที่เกิดเหตุซึ่งเป็นทางแยก รถคันที่2 ได้ชลอความเร็ว เพื่อจะเลี้ยวไปทาง อ.บ้านตาก ทางหลวงหมายเลข 1175 ทำให้รถคันที่ 1 วิ่งมาด้วยความเร็วเบรดไม่ทัน ทำให้รถทั้ง 2 คัน เฉี่ยวชนกันเป็นเหตุให้มีผู้ได้รับบาดเจ็บเป็นเด็กชาย 1 คน และไปเสียชีวิตที่โรงพยาบาลแม่ระมาด ทรัพย์สินของเอกชนไม่ทราบราคา ส่วนทรัพย์สินของทางราชการเสียหาย มีไฟฟ้าแสงสว่าง จำนวน 1 ต้น มูลค่า 36,800 บาท เหตุเกิดที่ท้องที่ ต.แม่ระมาด อ.แม่ระมาด จ.ตาก

ลงชื่อ .... ผู้รายงาน
(..)
ตำแหน่ง ....
วันที่ .... เดือน .... พ.ศ. ....

ลงชื่อ .... ผู้รายงาน
(..)
ตำแหน่ง ....
วันที่ .... เดือน .... พ.ศ. ....

Figure 12.12: Summary of crash site data

12.4 Development of a Traffic Accident Database in Japan

12.4.1 Introduction

Traffic accident statistics compiled by the National Police Agency (NPA) in Japan are useful for identifying accident trends (NPA 2011a and b). However, this data does not include details of the precise location of the accident. As a result, another system of reporting accident data is required. The Traffic Accident Database is an example of such a database. It includes traffic accident, traffic condition and road alignment data so that the relationships between traffic accidents and traffic condition, and between traffic accidents and road alignment, can be examined.

12.4.2 Background

When a traffic accident (fatal and injury accident) occurs in Japan, the Police visit the scene of the accident in response to reports from the involved parties. Their task is to investigate the circumstances of the accident and to prepare a report, including an on-scene investigation report/drawings of the accident. The Police also interview those who were involved in the accident about the way it occurred and its causes. They then prepare an investigator's report based on the oral statements. Based on these records, the Police may then make a decision to lay with criminal charges against someone involved in the accident.

This accident investigation procedure is required before payment of accident liability insurance (both 'the compulsory insurance portion required by law' and 'the optional insurance portion not required by law') can be made.

The data can be used to macroscopically clarify the characteristics of the accidents. As a result, the national government and prefectural administrations can use the data to propose integrated traffic safety measures and to evaluate their effectiveness.

The type of traffic accident statistics published varies according to the type of report as shown in Table 12.2, whilst the principal items aggregated in terms of the 'State of the Occurrence of Traffic Accidents' (Annual Report) are listed in Table 12.3.

Table 12.2: Contents of Traffic Accident Statistics (National Police Agency 2011a)

Reports	Traffic accident statistics
Semi-annual reports	Characteristics of fatal traffic accidents and state of regulation of violations of the Road Traffic Law during the first half of the year
Annual report	Number of traffic accident fatalities
	Characteristics of fatal traffic accidents and state of regulation of violations of the Road Traffic Law
	State of occurrence of traffic accidents
	Number of traffic accidents causing death within 30 days after the accident
Periodic reports	State of occurrence of traffic accidents at the end and beginning of the year
	State of occurrence of traffic accidents during the spring nationwide traffic safety campaign period
	State of occurrence of traffic accidents and motorcycle gang trends during the spring holiday period
	State of occurrence of traffic accidents during the ten day *obon* festival period in the summer
	State of occurrence of traffic accidents during the autumn nationwide traffic safety campaign period

Table 12.3: Principal Items Aggregated (National Police Agency 2011a)

Numbers of deaths and injuries by age group
Numbers of deaths and injuries by situation
Numbers of deaths and injuries by injured member
Number of traffic accidents by type of accident
Number of traffic accidents by day/night
Number of traffic accidents by type of involved party (primary involved party)
Number of traffic accidents by age of driver (primary involved party)
Number of traffic accidents by topography/road shape
Number of traffic accidents by road type
Number of traffic accidents by law violated by the driver (primary involved party)
Number of traffic accidents by speed of recognition of danger by driver (primary involved party)

Description

Integrated traffic accident database

Road managers can use traffic accident data to gain an understanding of the type of traffic accidents and changes in trends over time. As a result, the data can be effectively used to enact the *Basic Plan for Traffic Safety*, which is the core plan for the regulation of traffic and the implementation of measures to improve road safety in Japan.

However, the data cannot be used to identify the precise locations of frequent accidents because this data is not collected at the time of the accident. Special measures are therefore required if traffic safety measures are to be successfully implemented. As a result, the traffic accident statistical data and the road traffic census data have been combined to create the Integrated Traffic Accident Database.

Using this database, the locations of accidents can be identified and the characteristics of the road location where the accident occurred can be correlated with the traffic accident data.

Using a GIS system, the locations of traffic accidents can easily be displayed on a digital road map, thus enabling the traffic accident occurrences to be related to location (intersection and by section). An example is shown in Figure 12.13.

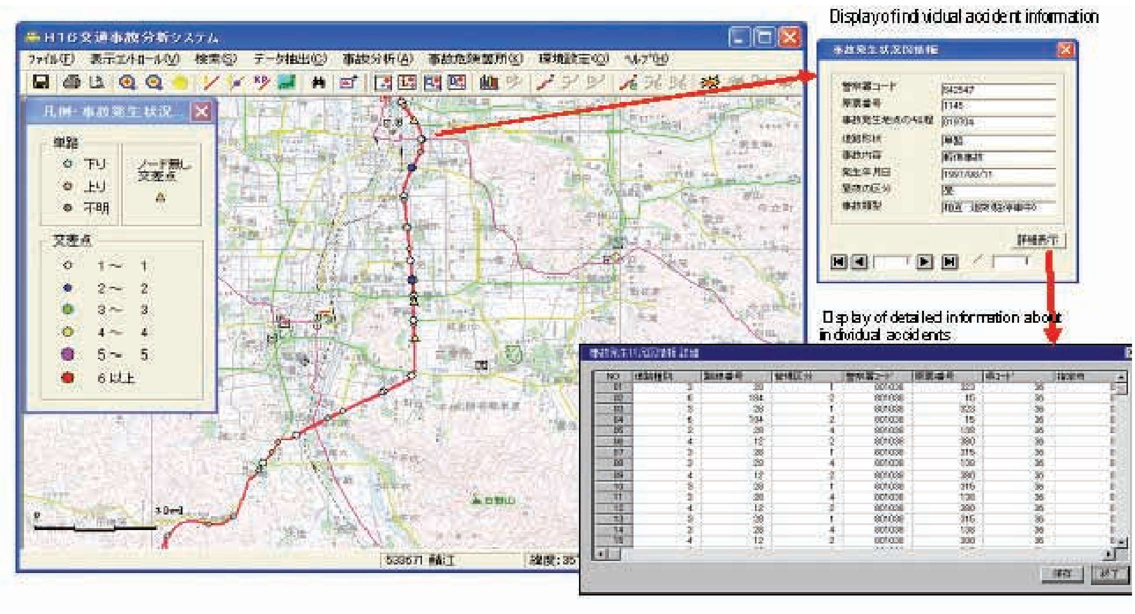


Figure 12.13: Map of locations of accidents (traffic accidents analysis system)

The traffic accident statistical data shown in Table 12.4 is stored in the database, permitting analysis at specific locations or within sections. This database is widely used to identify accident black-spots and to analyse the effectiveness of traffic safety measures.

Table 12.4: Traffic Accident Data Stored in Database

① Description of accident (numbers of fatalities, serious injuries, minor injuries)	⑦ Type of accident
② Date of accident	⑧ Purpose of travel (primary involved party, secondary involved parties)
③ Daytime or night-time	⑨ Type of action (primary involved party, secondary involved parties)
④ Age group (primary involved party, secondary involved parties)	⑩ Road geometric alignment
⑤ Road surface condition	⑪ Road shape
⑥ Types of involved parties (primary, secondary)	⑫ Road law infraction (primarily involved party)

Traffic accident measure database

The data and study results accompanying the traffic safety measure management flow, 'analysis of causes of accident → measure planning/implementation → measure effectiveness analysis' at accident black-spots introduced in case study 5.9.5 was used to build the database. The database is used by road managers to provide guidance on good practices in traffic safety measures. The features of the database include:

- reference to the most up-to-date information from throughout Japan
- it allows users to rapidly obtain the data they need via a search system
- the electronic format of the data allow users to carry out a range analyses.

Features of the database include:

- accident black-spots (3,956 locations designated in 2003)
- accident black-spots (part of 3,196 locations designated in 1996)
- other locations optionally registered (128 locations).

The principal contents registered:

- road structure before and after a measure was implemented (geometric alignment, number of vehicle lanes, etc.), state of traffic (traffic volume, signal indication), photos, accident occurrence diagram, etc.
- causes of accidents, state of occurrence of accidents
- process of planning measures (causes of accidents, measure planning process, etc.)
- evaluation of the effectiveness of the measures.

Example of search screens are show in Figure 12.14.

12.4.3 Expected Return

The Integrated Traffic Accident Database is a useful aid to identifying the locations where accidents occur frequently, whilst the development of the Traffic Accident Measure Database assists road managers to plan and implement traffic safety measures.

The more data collected regarding the effectiveness of traffic safety measures, the more effective the Traffic Accident Measure Database will become. It is therefore vital to continue to collect data and to enter it into the database even though this incurs some costs.

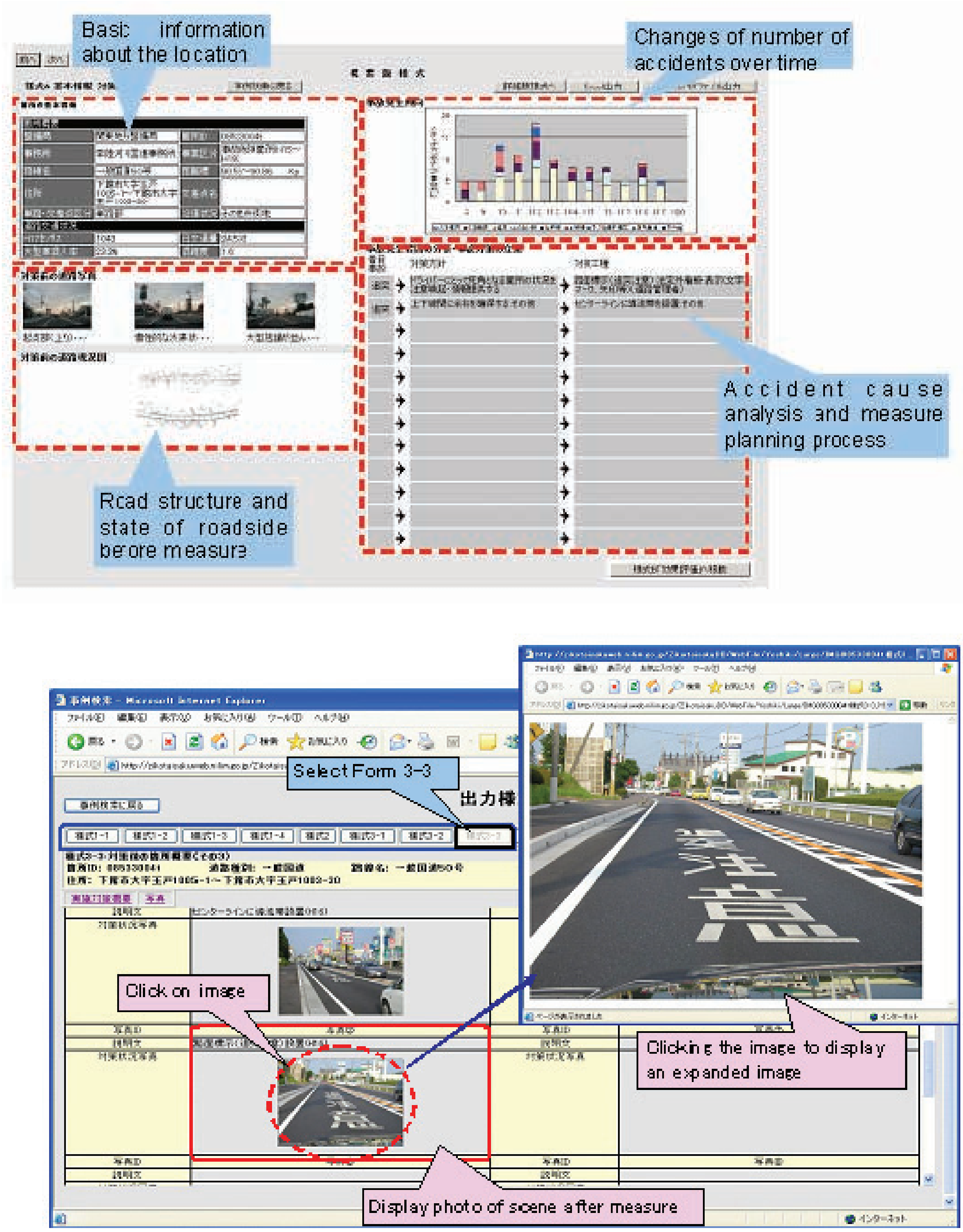


Figure 12.14: Example of search screens

References

Institute for Traffic Accident Research and Data Analysis 2011, *Annual report of State of occurrence of traffic accidents in 2010*, September.

National Police Agency 2011a, *Traffic State in 2010 (Annual Report)*.

National Police Agency 2011b, *Using traffic accident measure database for the management of the effective traffic safety business*, Civil Engineering Journal, vol. 53, December.

National Institute for Land and Infrastructure Management 2002, *Macro traffic accident analysis using the comprehensive database for traffic accidents*, Technical note no. 48, March.

National Institute for Land and Infrastructure Management 2004, *Guideline for improving road safety at Hazardous Spots – from the point of view of infrastructure*, Technical note no. 165, March.

12.5 Development of MIROS Road Accident Analysis & Database System (MROADS) and its Applications in Road Safety Research and Interventions

12.5.1 Introduction

Road crashes are recognized as a serious problem in Malaysia. The number of fatalities due to road crashes in Malaysia has been consistently above 6,000 over the past few years. Although the fatality index and rates are declining, the actual number for mortality and morbidity due to road crashes is still alarmingly high. Whilst the government has introduced several interventions over the past few years to tackle the issue on road safety, the number of fatalities and road crashes has not reduced as hoped.

12.5.2 Issues

In identifying and evaluating road safety, researchers and professionals are sometimes not equipped with the necessary specific information in relation to road crash patterns and causations. This lack of information would ultimately lead to ineffective road safety programs and interventions would therefore not provide as positive an impact as expected. Assessment of previous crash data records are needed to effectively identify the associated factors contributing to road crashes.

In Malaysia, the Royal Malaysian Police (PDRM) plays a major role in road crash data collection. A total of 91 variables are collected for each road crash. As there are more than 300,000 road crashes in Malaysia annually, there is an abundance of crash data available for analysis. However, the existing road crash data system used by PDRM is more focused on record keeping and management so the potential use of the crash data for research is not fully explored. There is therefore a need for a road crash intelligence system to help in organizing and analysing the data.

12.5.3 Specific Intervention

A new system was developed by MIROS to take advantage of the available road crash data. The new system, the *MIROS Road Accident Analysis & Database System (MROADS)*, is capable of providing automated road crash data analysis. An additional function in MROADS includes multi-dimensional cross-tabulation, black-spot identification and ranking, location mapping via Google maps, kilometre post-analysis, record management and report generation. The 91 items gathered by the PDRM were structured and segregated and stored in a centralized database. The provision of better structured data will create conditions which enable more in-depth analysis, and hence assist in the formulation of research and interventions.

The development of MROADS is also in line with national activities as suggested in the plan for the Decade of Action for Road Safety 2011-2020. Under the first pillar (road safety management), intelligence provided from MROADS analysis provides the government with the capacity to: (1) develop and coordinate the delivery of national road safety strategies, plans and targets, (2) produce and conduct evidential research to assess countermeasures designed to address road safety problems, and (3) monitor the implementation of road safety countermeasures and their effectiveness. This could only be achieved by having systematic road crash data collection and a system for the comprehensive analysis of that data.

12.5.4 Intended Outcome

The objective of MROADS is to provide road safety stakeholders with accurate, continuous and comprehensive information on road traffic accidents. The project was initiated because road crash data was not being fully utilized for decision-making and performance monitoring due to the unavailability of a comprehensive system which could perform extensive and detailed analysis. The intention underpinning the development of MROADS was to simplify the use of crash data to provide intelligence. As a result, crash data will now be fully utilised and will no longer be used for record keeping only. MROADS will address the issue of organizing nationwide data compilation as well as data analysis for intelligence in decision-making.

In addition, with the development of MROADS, it is hoped that road safety policies and interventions will be more evidence-based. MROADS will assist researchers and decision-makers to implement interventions to improve road safety throughout the country. Targeted programs can lead to effective treatments to specific road safety issues. In a similar way to other public health problems, road safety issues must be addressed through evidence-based interventions including changes at the policy level. MROADS is targeted to be the catalyst in road safety research providing the necessary input to assist in the formulation of effective policies and interventions in Malaysia.

12.5.5 Description

Once the development process was completed, historic and new crash data obtained from the PDRM was stored into the MROADS database. Users have the capability to easily retrieve and analyse crash data by using the user-friendly graphical interface. Most of the work conducted to relate the application and the database was conducted in the background and the users do not need to understand the Structured Query Language (SQL) that was used to query the database in order to retrieve the data. The interface protects the database by rejecting faulty commands given by the user that might damage the database.

A summary of the functions built into MROADS is presented in Table 12.5 whilst the splash map screen is displayed in Figure 12.15.

Table 12.5: Summary of Functions Built into MROADS

Feature	Function
Cross-tabulation	Display two accident variables simultaneously, with set condition capability
Accident location ranking	Identify frequent accident locations; locations can be ranked according to four different scopes: district, route number, coordinate number and road name, with set condition capability
Set condition	Complement cross-tabulation analysis and location ranking by enabling the user to set their specific requirements based on all the 91 accident data variables
Location mapping	Achieved via Google maps. The user has the ability to map the locations analysed from a location ranking module
Accident record management	Fundamental record management such as adding a new record, editing and deleting existing records as well as viewing accident records
Database management	Add a new database or remove the existing database
User management	Add or remove a user from the system and set user privileges
Data converter	Convert the accident data in the text file format received from the Royal Malaysian Police and upload it to the MROADS database server
Export	Export the result to Microsoft Excel or graph for reports preparation
Print	Print the displayed result

A function that is regularly used for road safety analysis is cross-tabulation. Cross-tabulation displays the result of two accident variables simultaneously with optional set condition capability. The set condition will enable flexibility in the data query as more in-depth analysis can be carried out. For example, a user may need to identify all entities in the database that meet his/her specifications such as all accidents involving motorcycles, not wearing a helmet, accidents after midnight and accidents on rainy days. Having the ability to query with specific details enables specific information to be retrieved thus enabling specific research to be carried out or an appropriate intervention developed. An example of cross-tabulation of casualty by age for drivers from the MROADS output is shown in Figure 12.16.

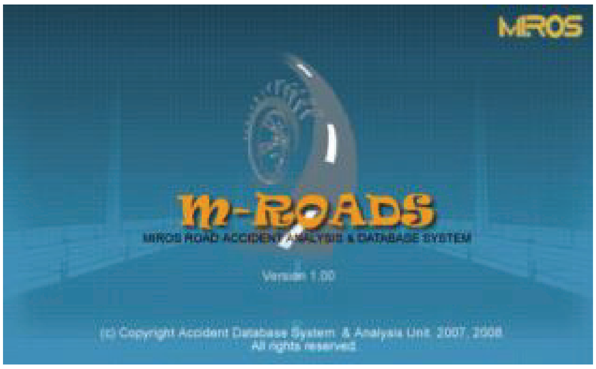
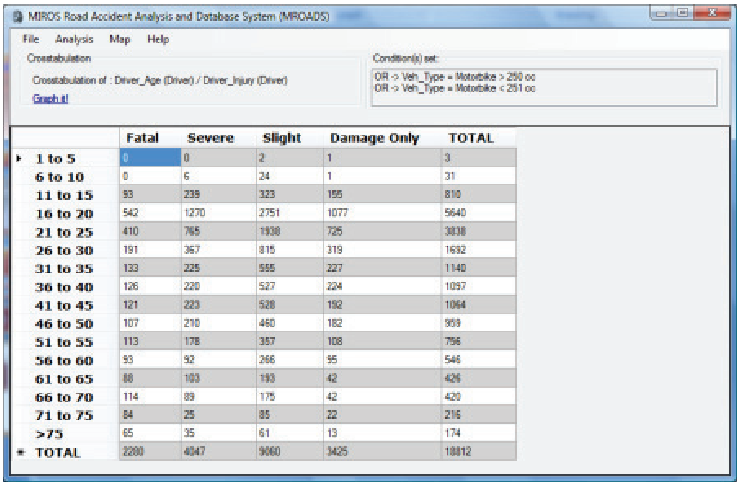


Figure 12.15: MROADS splash screen



MIROS Road Accident Analysis and Database System (MROADS)

File Analysis Map Help

Crosstabulation

Crosstabulation of : Driver_Age (Driver) / Driver_Injury (Driver)

Graph it!

Condition(s) set:

OR -> Veh_Type = Motorbike > 250 cc
OR -> Veh_Type = Motorbike < 251 cc

	Fatal	Severe	Slight	Damage Only	TOTAL
1 to 5	0	0	2	1	3
6 to 10	0	6	24	1	31
11 to 15	93	239	323	155	810
16 to 20	542	1270	2751	1077	5640
21 to 25	410	765	1938	725	3838
26 to 30	191	367	815	319	1692
31 to 35	133	225	555	227	1140
36 to 40	126	220	527	224	1097
41 to 45	121	223	528	192	1064
46 to 50	107	210	460	182	959
51 to 55	113	178	357	108	756
56 to 60	93	92	266	95	546
61 to 65	88	103	193	42	426
66 to 70	114	89	175	42	420
71 to 75	84	25	85	22	216
>75	65	35	61	13	174
TOTAL	2280	4047	9060	3425	18812

Figure 12.16: Cross-tabulation of casualty by age for drivers from MROADS output

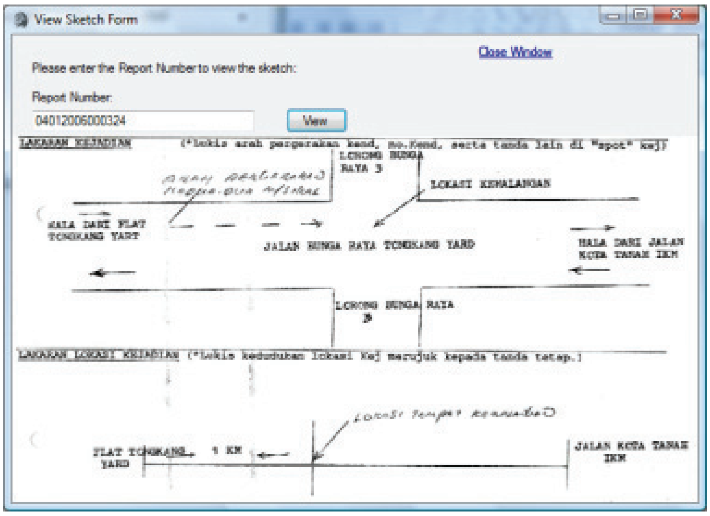


Figure 12.17: Sketch diagram output

Displaying the accident information in MROADS is achieved by translating the numeric figure that represents variable names in the database to a textual format. The process of translation is carried out by mapping each of the numeric values to its text, with the text displayed to the user instead of the numeric value (Figure 12.17). The mapping index files are saved in a text file format and accessed each time the data is retrieved. Each of the variables that are coded in numeric form maintains a single separate text file. Therefore, should there be a need to edit the variables; the user can do this easily and instantaneously via the text files.

12.5.6 Use of MROADS

The development of MROADS has assisted in hypothesis building for addressing road safety problems and the provision of evidence of the existence of the problem and its severity. In a broader context, high impact road safety interventions may be introduced based on evidence produced by MROADS. For example, the Automated Enforcement System (AES) was introduced to tackle the issue of speeding and traffic light violation. Crash data from MROADS was used to identify more than 700 locations throughout the country with high fatality and crashes due to speeding or traffic-light violations. As a result, electronic enforcement cameras will be installed at these locations. Warning signs will alert drivers to the enforcement cameras ahead, motivating them to slow down to the speed limit or obey the traffic light. It is estimated that AES may reduce the number of overall fatalities by 9%.

In addition to road safety research and interventions, MROADS assists the enforcement agencies to build strategies and carry out effective enforcement under the concept of 'Evidence-based Enforcement'. The concept utilizes the crash data to provide evidence of the main road safety issues and how enforcement can help. For example, the fatality rate among motorcyclists in Malaysia is very high – the result of their vulnerability and involvement in 'out of control' and 'side impact' collisions. Further investigation identified that most injuries were to the head, suggesting that helmet wearing should be enforced. The question of when and where enforcement should be carried out can be identified for each state or district using MROADS. This means that enforcement is evidence-based rather than being carried out intuitively.

For the Community Based Programme – Helmet Initiative, MROADS identified areas in each State of Malaysia with high fatalities associated with head injuries to motorcyclists. A helmet wearing campaign was run, including the issuing of free helmets to riders to encourage them to wear a helmet. The performance of the program, evaluated in terms of helmet wearing compliance and head injuries after the campaign, showed a positive result.

Crash data is also used to monitor the performance of the road safety programs and interventions. One of the main indicators of the effectiveness of the programs or interventions is the reduction in the number of road accidents. MROADS is used to evaluate the programs and interventions by examining the road crash statistics and trends after the implementation of a counter-measure.

12.5.7 Cost and Returns

The costs associated with the development of MROADS were very small and mainly related to the development of the system. The road crash data is already collected by the Royal Malaysian Police, and the MROADS database is currently updated monthly. Additional personnel are required to ensure that only data quality is input into the MROADS database.

12.5.8 Summary

The development of MROADS has revolutionized the use of road crash data in Malaysia. All the feedback from stakeholders has been positive. Researchers in MIROS rely heavily on the system to identify key road safety issues and to help in formulating targeted research. Decision-makers such as members of Parliament, MIROS, PDRM, JPJ, and JKJR also use the outputs to assist in decision-making. Key industry players such as car manufacturers use the crash data to improve the design of their products. In addition, researchers from other institutions also benefit from the various outputs of MROADS. The development and success of MROADS is featured in the *Good Practice Data System Manual* published by the World Health organisation (WHO) and avauilable from the Global Transport Knowledge Partnership (gTKP) library.

MROADS was also awarded first prize in the road safety category in the *Innovation Award for Road Transport in Developing Countries (INAROAD)* in 2010 and overall third prize in the competition.

12.6 Road Accident Data Collection and Analysis in Brunei

12.6.1 Introduction

Pillar 1 of the *Global Plan for Road Safety* emphasizes road safety management. In the context of Brunei, this is associated with the Brunei National Road Safety Council's (BNRSC's) organizational structure, capacity and capability building programs, including the development of a road accident database to support research activities. Between 80% and 85% of the total vehicle fleet in Brunei Darussalam consists of private cars. However, the use of two-wheeled vehicles (i.e. motorcycles and bicycles) is increasing.

The variation in road traffic accident casualty rates per 100,000 population – and the death rate per 10,000 licensed vehicles in Brunei Darussalam – over time is shown in Figure 12.18 and Figure 12.19 respectively. These data were assembled by the Centre for Road Safety Studies, Institut Teknologi Brunei (ITB) utilizing all currently available resources.

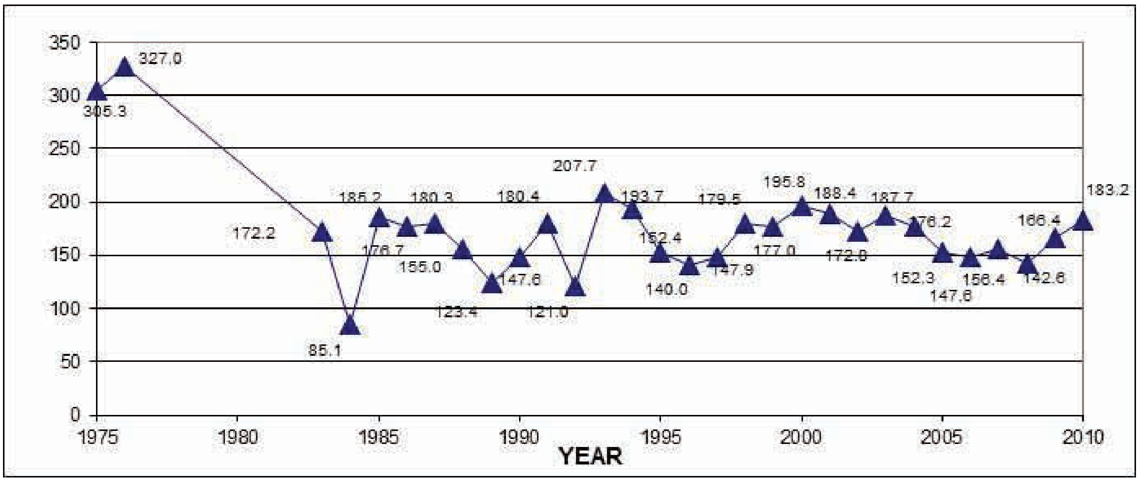


Figure 12.18: Variation in casualty rate per 100,000 population over time

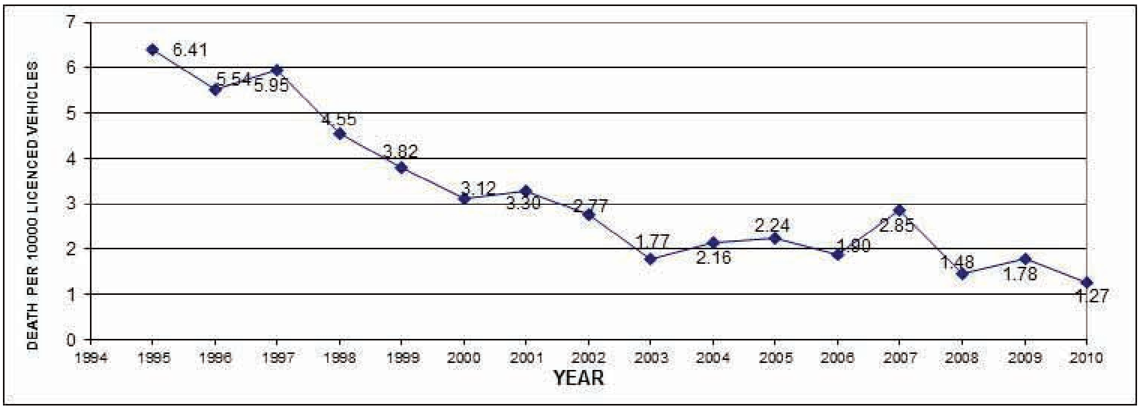


Figure 12.19: Variation in death rate per 10,000 licensed vehicles over time

12.6.2 Review of Royal Brunei Police Database and Establishment of CARS

Royal Brunei Police Data

It was found that the available data was slightly disorganised and in some cases unavailable or incomplete. In 2000 and 2001, the ITB explored the Royal Brunei Police (RBP) road accident database and identified a number of issues, including:

- 64.2% of the accidents were associated with human error, e.g. run offs at junctions
- 9.5% of the accidents were associated with the road infrastructure, e.g. slippery roads
- 3% of the accidents were associated with other modes

- only a small percentage of the accidents (0.6%) could be related to vehicle design
- another 22.7% of the data could not be assigned to any cause.

As a result, it was recommended that the on-site recording and the off-site collation of data needed to be improved and that more user-friendly data recording and management systems needed to be developed. Although there are many database systems available, it was considered that the establishment of a systematic database was vital if the system was to be accepted and understood by the local police force personnel and other stakeholders.

Establishment of CARS

An example of such a system is the Microcomputer Accident Analysis Package (MAAP) established by the Royal Malaysian Police (PDRM) to manage accident data. MAAP is an accident data management system based on the DOS operating system. As technology progressed, in 1997, the PDRM introduced a new Windows-based system called Computerized Accident Recording System (CARS) to manage the accident data though the use of MAAP still continued. In 2005, MAAP was terminated and CARS is now used to manage the data. CARS is also capable of performing record maintenance and cross-tabulation analysis to provide general road accident statistics.

12.6.3 Project Description

Various efforts have been planned and implemented by the BNRSC and its stakeholders to improve road safety conditions in Brunei. It is well understood that a prerequisite to improve road safety is to have a comprehensive road accident database and analysis system. Quality, accurate and reliable data collected over a long period of time is necessary if the factors that influence the road accidents can be properly identified and understood. As Brunei is supporting the *Decade of Action for Road Safety 2011-2020*, it is important for Brunei to have an advanced road accident analysis system to help strategize road safety initiatives and gain a better understanding of the factors that contribute to accidents. Furthermore, accident data is critical if the effectiveness of road safety interventions introduced by the Government and non-Government organisations through the BNRSC are to be monitored and evaluated.

The Centre for Road Safety Studies (CRoSS) has submitted a proposal entitled ‘Road Accident Data Enhancement and Development (RADED)’ for immediate implementation. As already discussed, an improved accident database system is fundamental to road safety research; it can only be obtained with the cooperation of the RBP and other relevant agencies. The aim of RADED is to enhance the current data collation and analysis by working together with the RBP and other relevant agencies to develop a framework of a future Brunei Road Accident Database System.

The project will involve the following four stages:

1. Review on-site and off-site data recording and analysis.
2. Enhance on-site/off-site data programs.
3. Design a data Computerization and database framework using available GPS, GIS or other database systems.
4. Develop a road accident database and analysis framework, tentatively named BruROADS using GIS and other relevant databases.

12.6.4 Expected Outcomes

Completion of this project is expected to have significant outputs, including:

- manual or semi-manual to computerised datasets
- the application of ICT and other technology to upgrade the current manual or semi-manual systems

- more consistent data output and data extraction and utilisation and hence faster retrieval and decision-making.

The source of data is expected to be the RBP road accident systems. Factors influencing accidents, including the road environment, the vehicle and road users would be collected using the newly-revised form or a form completed using a palm computer or equivalent that would only involve circling or ticking actions to ensure fast and accurate on-site recording. There will also be instances where absolute figures are required such as the width of the road shoulder or property damage cost that would need to be filled in the relevant section. The on-site accident data will then be transferred to new database systems (BruROADS). There will also be data not incorporated within the system such injuries. BruROADS will explore the possibility of incorporating this data in close consultation with the Department of Health of the Ministry of Health.

It is expected that BruROADS to be able to:

- provide a centralized accident database system for nationwide record management
- have road accident displaying mode tools
- provide outputs, either in the form of figures, graphs, maps or diagram/sketches.

Depending on the base system finally adopted, some of the examples of expected outputs of BruROADS will include:

- computerised datasets and subsequently the design of databases that include standard parameters (Figure 12.20)
- a depiction of accident-prone roads (Figure 12.21)
- a display of road accident hotspots on a GIS or other relevant platform (Figure 12.22).

MODE
SA – Self Accident
2V = Two-vehicle accident or more
VBM = Veh. With Bicycle/Motorcycle
VP = Veh. With Pedestrians
VA = Veh. with Animas

RD TYPE
2 Way 1 Lane
Dual
Compound
Car Park

REFERENCE				LOCATION					Conditions	DEGREE OF INJURY			
date	time (24 hours)	Report No	police code	RoadName	Rdtype	Chainage	Direction	Crash Type	Weather	Death	Serious	Minor	No injury
12/2/2008	15:50	LB/TR/18/2008		Jln Labi	2 Way 1 Lane	Kg Batu 5		VA					1
11/9/2008	15:05	LB/TR/17/2008		Jln Labi	2 Way 1 Lane	Kg Batu 5		SA	heavy rain				1
9/25/2008	0:05	LB/TR/15/2008		Jln Labi	2 Way 1 Lane	Kg Tenajor Paten		VA				1	
[illegible]	[illegible]	LB/TR		Jln Labi	2 Way 1 Lane	KM42, Kg [illegible]		VA					1
8/16/2008	00:00 - 08:00	LB/TR		Jln Labi	2 Way 1 Lane	Jln Serbatu Halus, Kg Dangtaung		SA					1
7/28/2008	6:50	LB/TR		Jln Labi	2 Way 1 Lane	Jln Lurus, Kg Bukit Puan		SA					1
6/2/2008	21:00	LB/TR		Jln Labi	2 Way 1 Lane	Jln Kg Sungai Mau		VA					1
5/11/2008	20:00	LB/TR		Jln Merangking	2 Way 1 Lane	Dkt Spg Sekolah Rendah Bukit Sawat	towards Sg Liang	SA	raining				2
5/10/2008	13:15	LB/TR		Jln Labi	2 Way 1 Lane	Jln Balak, Bukit Telingan							
3/9/2008	18:58	LB/TR		Jln Kg Teraja	2 Way 1 Lane	KM 3 Teraja Labi (jalan berselekeh)		SA	hujan				1
1/27/2008	9:15	LB/TR			2 Way 1 Lane	Jln Kecil Gatas		VA					1

Figure 12.20: Computerised datasets and subsequently the design of databases that include standard parameters

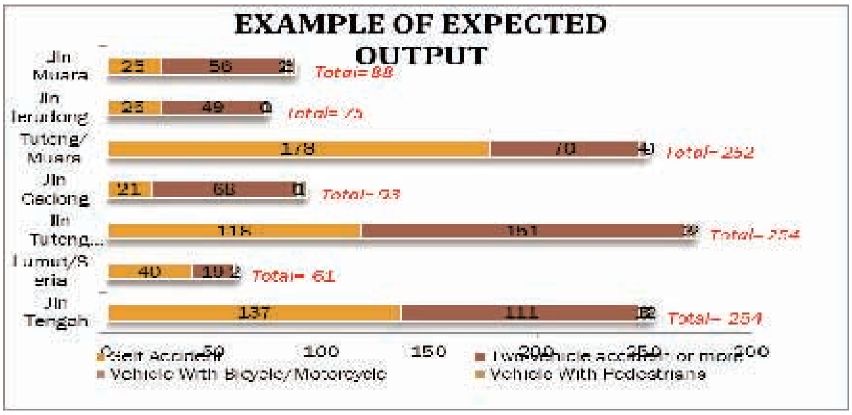


Figure 12.21: Bar-chart of accident-prone roads

Figure 12.22: Display of road accident hotspots on a GIS or other relevant platform

APPENDIX A DECADE OF ACTION – PILLARS

The pillars, and related activities, are described in more detail in United Nations (2010). A brief summary of the objective of the five Pillars follows.

A.1 Pillar 1: Road Safety Management

Adhere to and/or fully implement UN legal instruments and encourage the creation of regional road safety instruments. Encourage the creation of multi-sectoral partnerships and designation of lead agencies with the capacity to develop and lead the delivery of national road safety strategies, plans and targets, underpinned by the data collection and evidential research to assess countermeasure design and monitor implementation and effectiveness. Activities include the following:

1. Adhere to and/or fully implement the major United Nations road safety related agreements and conventions; and encourage the creation of new regional instruments similar to the European Agreement concerning the Work of Crews of Vehicles engaged in International Road Transport (AETR), as required, including:
   a. Convention on Road Traffic, of 8 November 1968, aiming at facilitating international road traffic and at increasing road safety through the adoption of uniform road traffic rules
   b. Convention on Road Signs and Signals, of 8 November 1968, setting up a set of commonly agreed road signs and signals
   c. AETR of 1 July 1970 to be used as a model the creation of regional legal instruments.
2. Establish a lead agency (and associated coordination mechanisms) on road safety involving partners from a range of sectors through:
   a. designating a lead agency and establishing related secretariat
   b. encouraging the establishment of coordination groups
   c. developing core work programs.
3. Develop a national strategy (at a cabinet or ministerial level) coordinated by the lead agency through:
   a. confirming long-term investment priorities
   b. specifying agency responsibilities and accountabilities for development and implementation of core work programs
   c. identifying implementation projects
   d. building partnership coalitions
   e. promoting road safety management initiatives such as the new ISO traffic safety management standard ISO 39001
   f. establishing and maintaining the data collection systems necessary to provide baseline data and monitor progress in reducing road traffic injuries and fatalities and other important indicators such as cost, etc.
4. Set realistic and long-term targets for national activities based on the analysis of national traffic crash data through:
   a. identifying areas for performance improvements
   b. estimating potential performance gains.
5. Work to ensure that funding is sufficient for activities to be implemented through:
   a. building business cases for sustained funding based on the costs and benefits of proven investment performance
   b. recommending core annual and medium-term budgetary targets
   c. encouraging the establishment of procedures for the efficient and effective allocation of resources across safety programs
   d. utilizing 10% of infrastructure investments for road safety

e. identifying and implementing innovative funding mechanisms.

6. Establish and support data systems for on-going monitoring and evaluation to include a number of process and outcome measures, including:
    a. establishing and supporting national and local systems to measure and monitor road traffic deaths, injuries and crashes
    b. establishing and supporting national and local systems to measure and monitor intermediate outcomes, such as average speed, helmet-wearing rates, seat-belt wearing rates, etc.
    c. establishing and supporting national and local systems to measure and monitor outputs of road safety interventions
    d. establishing and supporting national and local systems to measure and monitor the economic impact of road traffic injuries
    e. establishing and supporting national and local systems to measure and monitor exposure to road traffic injuries.

A.2 Pillar 2: Safer Roads and Mobility

Raise the inherent safety and protective quality of road networks for the benefit of all road users, especially the most vulnerable (e.g. pedestrians, bicyclists and motorcyclists). This will be achieved through the implementation of various road infrastructure agreements under the UN framework, road infrastructure assessment and improved safety-conscious planning, design, construction and operation of roads. Activities include the following:

1. Promote road safety ownership and accountability among road authorities, road engineers and urban planners by:
    a) encouraging governments and road authorities to set a target to “eliminate high risk roads by 2020
    b) encouraging road authorities to commit a minimum of 10% of road budgets to dedicated safer road infrastructure programs
    c) making road authorities legally responsible for improving road safety on their networks through cost-effective measures and for reporting annually on the safety situation, trends and remedial work undertaken
    d) establishing a specialist road safety or traffic unit to monitor and improve the safety of the road network
    e) promoting the safe system approach and the role of self-explaining and forgiving road infrastructure
    f) Adhere to and/or fully implement the regional road infrastructure Agreements developed under the auspices of the United Nations regional commissions and encourage the creation of similar regional instruments, as required
    g) monitoring the safety performance of investments in road infrastructure by national road authorities, development banks and other agencies.

2. Promote the needs of all road users as part of sustainable urban planning, transport demand management and land-use management by:
    a) planning land use to respond to the safe mobility needs of all, including travel demand management, access needs, market requirements, geographic and demographic conditions
    b) including safety impact assessments as part of all planning and development decisions
    c) putting effective access and development control procedures in place to prevent unsafe developments.

3. Promote safe operation, maintenance and improvement of existing road infrastructure by requiring road authorities to:

a) identify the number and location of deaths and injuries by road user type, and the key infrastructure factors that influence risk for each user group
b) identify hazardous road locations or sections where excessive numbers or severity of crashes occur and take corrective measures accordingly
c) conduct safety assessments of existing road infrastructure and implement proven engineering treatments to improve safety performance
d) take a leadership role in relation to speed management and speed sensitive design and operation of the road network
e) ensure work zone safety.

4. Promote the development of safe new infrastructure that meets the mobility and access needs of all users by encouraging relevant authorities to:
   a) take into consideration all modes of transport when building new infrastructure
   b) set minimum safety ratings for new designs and road investments that ensure the safety needs of all road users are included in the specification of new projects
   c) use independent road safety impact assessment and safety audit findings in the planning, design, construction, operation and maintenance of new road projects, and ensure the audit recommendations are duly implemented.
5. Encourage capacity building and knowledge transfer in safe infrastructure by:
   a) creating partnerships with development banks, national authorities, civil society, education providers and the private sector to ensure safe infrastructure design principles are well understood and applied
   b) promoting road safety training and education in low-cost safety engineering, safety auditing and road assessment
   c) developing and promoting standards for safe road design and operation that recognize and integrate with human factors and vehicle design.
6. Encourage research and development in safer roads and mobility by:
   a) completing and sharing research on the business case for safer road infrastructure and the investment levels needed to meet the Decade of Action targets
   b) promoting research and development into infrastructure safety improvements for road networks in low-income and middle-income countries
   c) promoting demonstration projects to evaluate safety improvement innovations, especially for vulnerable road users.

A.3 Pillar 3: Safer Vehicles

Encourage the universal deployment of improved vehicle safety technologies for both passive and active safety through a combination of harmonisation of relevant global standards, consumer information schemes and incentives to accelerate the uptake of new technologies. Activities include the following:

1. Encourage Member States to apply and promulgate motor vehicle safety regulations as developed by the United Nation’s World Forum for the Harmonization of Vehicle Regulations (WP 29).
2. Encourage the implementation of new car assessment programs in all regions of the world in order to increase the availability of consumer information about the safety performance of motor vehicles.
3. Encourage agreement to ensure that all new motor vehicles are equipped with seat-belts and anchorages that meet regulatory requirements and pass applicable crash test standards (as minimum safety features).
4. Encourage universal deployment of crash avoidance technologies with proven effectiveness such as electronic stability control and anti-lock braking systems in motor vehicles.

5. Encourage the use of fiscal and other incentives for motor vehicles that provide high levels of road user protection and discourage import and export of new or used cars that have reduced safety standards.
6. Encourage application of pedestrian protection regulations and increased research into safety technologies designed to reduce risks to vulnerable road users.
7. Encourage managers of governments and private sector fleets to purchase, operate and maintain vehicles that offer advanced safety technologies and high levels of occupant protection.

A.4 Pillar 4: Safer Road Users

Develop comprehensive programs to improve road user behaviour. Implement sustained or increased enforcement of laws and standards, combined with public awareness/education to increase seat-belt and helmet wearing rates, and to reduce drink-driving, speed and other risk factors. Activities include the following:

1. Increase awareness of road safety risk factors and prevention measures and implement social marketing campaigns to help influence attitudes and opinions on the need for road traffic safety programs.
2. Set and seek compliance with speed limits and evidence-based standards and rules to reduce speed-related crashes and injuries.
3. Set and seek compliance with drink-driving laws and evidence-based standards and rules to reduce alcohol-related crashes and injuries.
4. Activity 4: Set and seek compliance with laws and evidence-based standards and rules for motorcycle helmets to reduce head-injuries.
5. Set and seek compliance with laws and evidence-based standards and rules for seat-belts and child restraints to reduce crash injuries.
6. Set and seek compliance with transport, occupational health and safety laws, standards and rules for safe operation of commercial freight and transport vehicles, passenger road transport services and other public and private vehicle fleets to reduce crash injuries.
7. Research, develop and promote comprehensive policies and practices to reduce work-related road traffic injuries in the public, private and informal sectors, in support of internationally recognized standards for road safety management systems and occupational health and safety.
8. Promote the establishment of Graduated Driver Licensing systems for novice drivers.

A.5 Pillar 5: Post-Crash Response

Increase responsiveness to post-crash emergencies and improve the ability of health and other systems to provide appropriate emergency treatment and longer term rehabilitation for crash victims. Activities include the following:

1. Develop pre-hospital care systems, including the extraction of a victim from a vehicle after a crash and implementation of a single nationwide telephone number for emergencies, through the implementation of existing good practices.
2. Develop hospital trauma care systems and evaluate the quality of care through the implementation of good practices on trauma care systems and quality assurance.
3. Provide early rehabilitation and support to injured patients and those bereaved by road traffic crashes, to minimise both physical and psychological trauma.
4. Encourage the establishment of appropriate road user insurance schemes to finance rehabilitation services for crash victims through:
   a. the introduction of mandatory third-party liability

   b. international mutual recognition of insurance, e.g. green card system.

5. Encourage a thorough investigation into the crash and the application of an effective legal response to road deaths and injuries and therefore encourage fair settlements and justice for the bereaved and injuries.
6. Provide encouragement and incentives for employers to hire and retain people with disabilities.
7. Encourage research and development into improving post-crash response.

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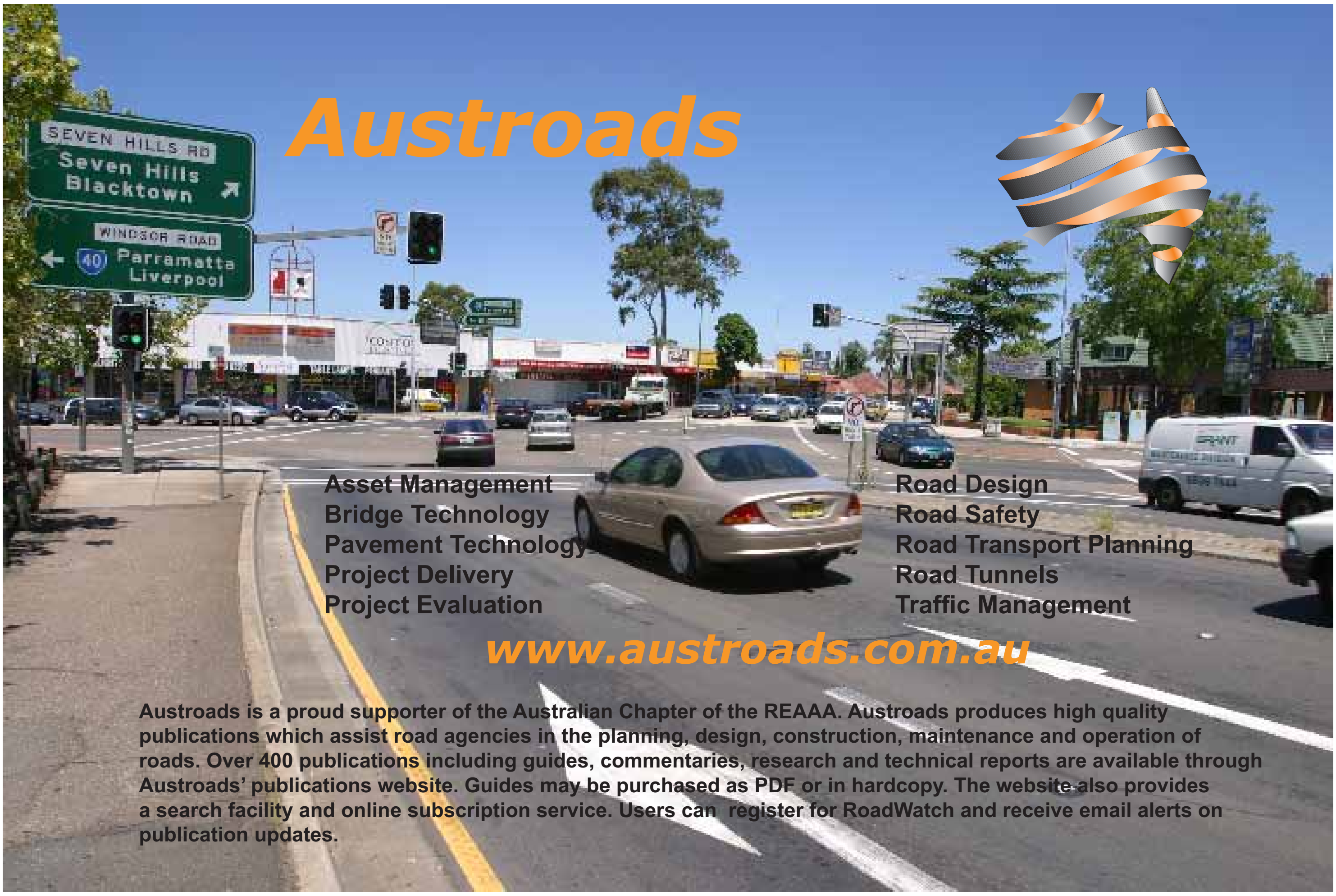
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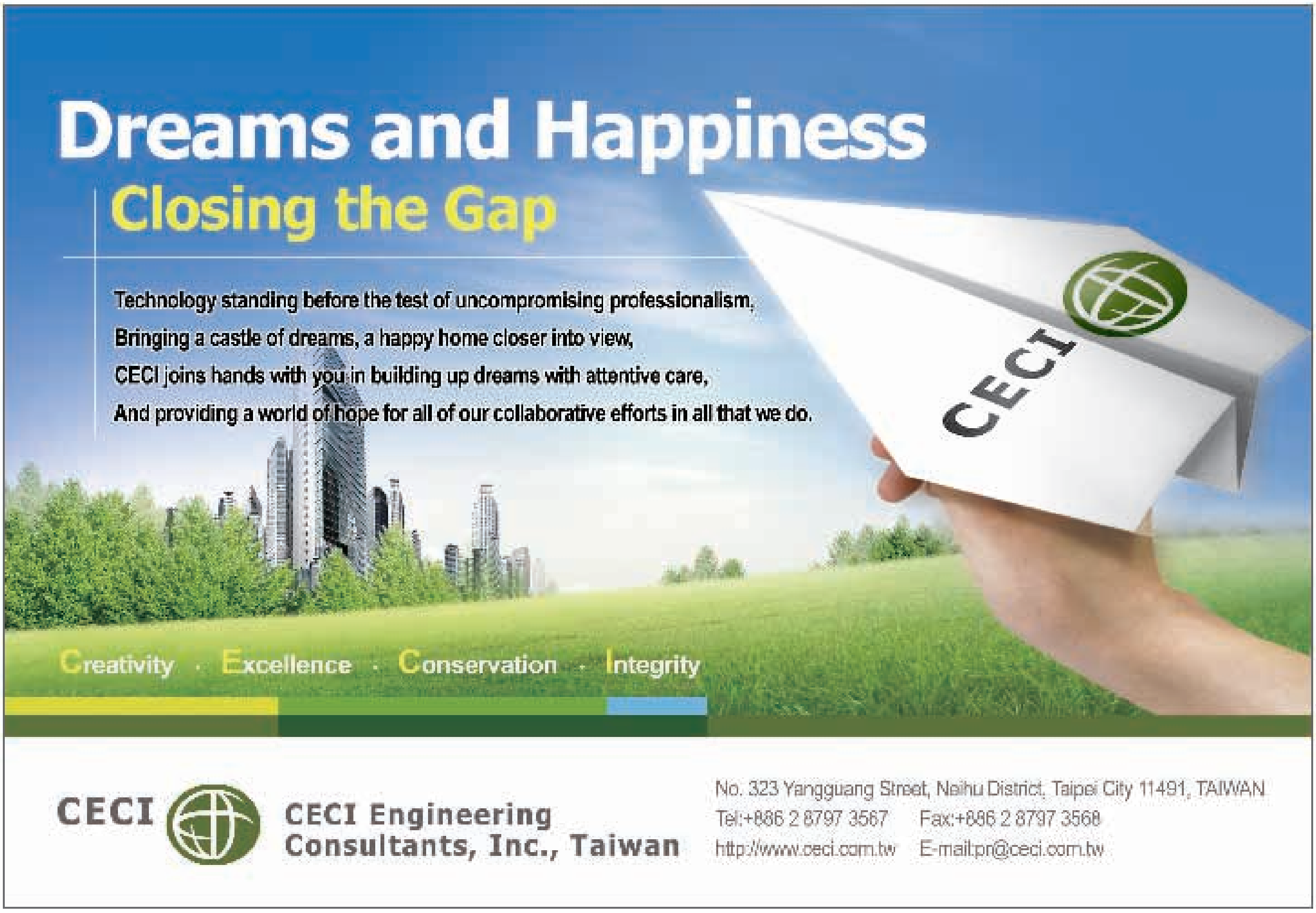

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INFORMATION RETRIEVAL

REAAA, 2011, **Compendium on Good Practices: Road Safety – Make it Happen**, Kuala Lumpur, TC-4, pp. 154.

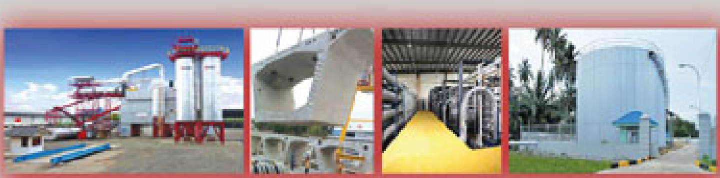
Keywords:

compendium/road safety/REAAA/accident statistics/case studies/

Abstract:

This *Compendium on Good Practices: Road Safety – Make it Happen* commences with an overview of the Decade of Action (2011-2020). This is followed by a compilation of accident statistics for each country in the region commencing from the year 2000 up to 2011. A series of case studies is then presented.

REAAA Report No: TC-4



" PT Jaya Konstruksi Manggala Pratama, Tbk, a member of the Jaya Group, operates a diverse portfolio of businesses that encompass the infrastructure and building construction sector, asphalt and liquefied petroleum gas (LPG) trading, precast concrete manufacturing and specialized mechanical and electrical engineering and maintenance services"

Jaya Konstruksi At a Glance

The Company was established on December 23, 1982, when the Contracting Division of PT Pembangunan Jaya was spun off to become a separate legal entity. The Company's shares have been listed on the Indonesia Stock Exchange (IDX) since December 2007.

The Company is a major player in Indonesia's infrastructure sector, having participated in many key projects and developments that have contributed to the country's social and economic growth, including airports,toll roads, power plants, water works and other public facilities. The Company also has a strong presence in the commercial sector as a leading provider of construction, engineering and maintenance services for hotels, malls, apartments and office buildings in Indonesia and overseas.

In 2007 the Company completed the acquisition of four direct subsidiaries, PT Jaya Trade Indonesia, PT Jaya Teknik Indonesia, PT Jaya Beton Indonesia and PT Jaya Daido Concrete, and subsequently acquired a further 12 indirect subsidiaries: PT Jaya Gas Indonesia, PT Toba Gena Utama, PT Sarana Bitung Utama, PT Metroja Mandiri, PT Kenrope Utama, PT Sarana Merpati Utama, PT Adibaroto Nugratama, PT Adigas Jaya Pratama, PT Sarana Lampung Utama, PT Sarana Lombok Utama, PT Sarana Jambi Utama and PT Jaya Celcon Prima.

The Company established two joint venture companies in 2009, PT Jaya Konstruksi Pratama Tol (with PT Pembangunan Jaya Toll) and PT Jaya Sarana Pratama (with PT Jaya Real Property Tbk) to pursue its interests in toll road construction and operation. To expand its bulk asphalt terminals, the Company established, through its subsidiary PT Jaya Trade Indonesia, PT Sarana Mbay Utama and PT Sarana Aceh Utama in 2009 and PT Sarana Sampit Mentaya Utama. To expand LPG trading business, established PT Kenrope Sarana Pratama in 2010 and PT Kenrope Utama Sentul in 2011. To develop mining business, established PT Sarana Sumber Daya Utama in 2011.

Also in 2010, the Company established, through its subsidiary PT Jaya Teknik Indonesia,two companies, PT Sarana Tirta Utama and PT Jaya Mitra Sarana, to pursue its interests in the water and waste management businesses.

In 2011, through our jointly owned subsidiary PT Jakarta Tollroad Development we joint several affiliated companies and other strategic partners to invest in the 6 Ruas Jalan Tol Dalam Kota Project-a major project to ease Jakarta's chronic traffic congestion by building six elevated toll roads above existing road, rail and waterways, thereby minimizing the need to acquire land for construction.

The Company's proven ability to harness its core capacities to integrate the infrastructure value chain enables it to enhance efficiency and reduce risks on even the most complex projects. With a strong reputation for high quality outcomes, reliability, on-time delivery and competitive pricing, Jaya Konstruksi has established itself as a leading partner for the Government of Indonesia and major corporations in infrastructure development.

JAYA KONSTRUKSI

Strive for the Best !

Kantor Taman Bintaro Jaya Gedung B, Jalan Bintaro Raya
Jakarta 12330, Indonesia
Phone : +62 21 736.3939 (Hunting) Fax. +62 21 736.3959
Email : info@jayakonstruksi.com
Website : http://www.jayakonstruksi.com

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