JABATAN KERJA RAYA
MALAYSIA

ROAD FACTS 2017

Reference Guide on Roads in Malaysia

Foreword I

Assalammualaikum w.b.t and Good Day,

A prosperous and expanding economy is greatly influenced by the extent and the state of the country's infrastructure network. By having a commendable road infrastructure, Malaysia has experienced where it has achieved a thriving economic development and industrialization. Development of road infrastructure involved high capital cost and its construction must therefore be economically viable with high rates of return. The network must provide comfortable riding quality for the road users with ever excellent and well maintained facilities. In the effort to achieve the standard, there are many challenges faced by the Public Works Department Malaysia (PWD Malaysia) in the planning, design, construction, and maintenance of road infrastructure.

Road Facts 2017 is published to provide many valuable and practical information on most issues relating to roads in Malaysia presented in a brief and easily accessible manner. The content of this document included information on road network, road development, maintenance and safety including relevant road design standards. It will enhance the knowledge of engineers especially for the beginners and may provide a good insight for others on road matters. It's also a good effort in encouraging the culture of knowledge sharing among the road fraternity and practitioners and at the same time it contributes to increase the number of PWD Malaysia's publications. The content should also be useful as a quick reference in any meetings or conferences in getting basic information on roads in Malaysia, should the matter arises.

Lastly, I would like to express my deepest appreciation and special thanks to those who have involved in the preparation of the Road Facts 2017. High tribute should also be given for their noble work, effort and contribution in ensuring the successful release of this document.

Thank you.

DATO' DR. MEOR AZIZ OSMAN
Senior Director
Road Branch
Public Works Department Malaysia
May 2017

Foreword II

Assalammualaikum w.b.t and Good Day,

It gives me a great pleasure to present to engineers and practitioners from the road engineering fraternity a book that provides brief and concise information about roads in Malaysia. Road Facts 2017 is published by Road and Bridge Engineering Department, Road Branch, Public Works Department Malaysia. For the number of staffs of more than one hundred and thirty people consisting almost 95% technicians and professionals in the field of road engineering, differences in level of knowledge and experiences are clearly seen among them in a working environment where prompt delivery of new projects must be adhered to.

I am confident that a book of this nature certainly would be a valuable reference and handy for road designers and practitioners especially those new engineers. This Road Facts 2017 provide current standards and practices in the design and construction of roads including in the fields of bridges and geotechnical engineering. The brief and vast information in this document would be very useful in assisting designers in making the right decisions and selecting the best design option.

Finally, I would like to express my sincere appreciation and gratitude to the members of the committee for their contributions and efforts towards the publication of this Road Facts 2017. I hope all the informations will prove to be an inspiring and truly beneficial for all of us.

Thank you.

DATO' IR CHE NOOR AZEMAN BIN YUSOFF
Director
Road and Bridge Engineering Department
Road Branch
Public Works Department Malaysia
May 2017

Editorial

Assalammualaikum w.b.t. and Salam Sejahtera,

Alhamdulillah, after a long deliberation and review on various subjects relating to road, finally, we have accomplished the task of producing the second publication of the Road Facts where the first publication was done back in 2010. In the midst of all the works and constraints faced, the effort to prepare this book has never rescinded. My greatest appreciation to all the committee members who have assisted and contributed in the effort. Not forgetting are the committed members of the secretariat who did the compiling, formatting and editing of this book.

After the first publication, this reference continues to be the interest to road engineers and also others outside the Cawangan Jalan. It was prepared for road designers and practitioners as a handy and quick reference guide for them in performing their daily works. The content consisting of basic information and simple guides, are selected as being commonly referred to by practitioners. While the intent of this book is to provide basic guidance on roads, the *Road Facts 2017* shall not be construed as a substitute for any engineering skill and judgement. Readers are encouraged to make references to existing guidelines for more detailed information.

All efforts have been made to present the latest available data in this book. However, readers may find that some of the data presented are behind time due to the non-availability of data at the time of preparing this book. Figures of the same data may differ as quoted by different sources. Nevertheless, I sincerely hope that this book continues to be the interest and valuable guide for those in need.

Thank you.

IR. HJ. ABDUL RAHMAN B. BAHARUDDIN
Chairman
Committee for the Preparation of 'Road Facts 2017'
Road Branch
Public Works Department Malaysia
May 2017

The Committee

COMMITTEE MEMBERS

1. Ir Hj Abdul Rahman Bin Baharuddin (**Chairman**)
2. Ir Hj Azhari Bin Shaharuddin
3. Ir Mohd Akhir Bin Ismail
4. Ir Hj Wan Abdul Rahman Bin Wan Hassan
5. Ir Razhiah Binti Wahab
6. Ir Mohamad Shukor Bin Che Malek
7. En Ahmad Fahmi Bin Hj Abdul Ghaffar
8. En Zaizul Hisham Bin Zainol
9. Ir Aminah Binti Ali
10. Pn Siti Nurilam Binti Abu Mansor
11. Ir Rohaida Binti Rashid
12. En Shahrul Nizam Bin Siajam
13. En Azali Bin Ardy
14. Pn Sue Alina Binti Abdul Aziz
15. Pn Norazura Binti Atan
16. Cik Zety Afrizan Binti Md Zaman
17. Ir Norhidayu Binti Kasim
18. En Ahmad Shairazi Bin Mohd Daud
19. En Mohd Fahmi Bin Mohd Sabri
20. Pn Siti Nur Azzwa Binti Razali
21. Cik Farah Zuhana Binti Zulkefle
22. En Mohd Faizal Bin Hamzah

SECRETARIAT

1. Pn Hanim Binti Saad
2. Pn Juliyanah Binti Sama'an
3. Pn Dila Farhana Binti Abu Bakar

Content

About Malaysia 1
- Malaysia in South Asia 3
- The States in Malaysia 4
- History in Brief 5
- Basic Facts 6
- Gross Domestic Product 7
- Key Indicators on Economy and Transportation 8
- Key Indicators in Demography 9

Road Infrastructure 11
- Road Construction in Malaysia 13
- Expenditure on Road Development 14
- Malaysia Road Development Index and Service Level 15

Road Network 17
- Malaysia Road Network 19
- Federal Road System 20
- Category of Federal Road 21
- Numbering System for Federal Roads 22
- Toll Expressways 23
- List of Toll Expressways and Concessionaire 24
- Numbers to Call in Case of Emergency 28
- State Road System 29
- Category of State Road and Numbering System 30

Road Maintenance 31
- About Road Maintenance 33
- Scope of Work for Routine Maintenance 34
- Scope of Work for Periodic Maintenance 36
- Scope of Work for Emergency Maintenance 37
- Maintenance Concessionaires – Federal Roads 38
- Maintenance Concessionaires – State Roads 39
- Bridges along Federal Roads 40
- Weight Restriction Order 41
- Maximum Permissible Vehicle Weight 43
- Pavement Condition Assessment 45
- Pavement Maintenance 46
- Bridge Maintenance 49
- Bridge Rehabilitation Methods 50
- Road Project Acceptance Criteria 51
- Who to Call 55

Road Safety 57
- Global Plan for the Decade of Action for Road Safety 2011 – 2020 59
- Road Safety Plan Malaysian 2006-2010 and Its Strategies 61
- Road Safety Plan Malaysian 2014-2020 and Its Strategies 62
- Our Rank in the World 63
- Alarming Facts about Global Road Traffic Accidents 65
- Malaysian Fatality Prediction 66

Content

Causes of Death in Malaysia	67
Road Accident Contributing Factors	68
Safe System Approach	69
Crash Risk and Crash Severity	70
Registered Vehicles and Their Involvement to the Road Traffic Accident	71
Types of Road Accident	72
Types of Casualty	73
Road Accident by States	74
Road Accident and Casualty by Road Category	75
Vehicles Involved in Road Accident	76
Speed Limit	77
6 Steps Procedure for Setting of Speed Limit	78
Speed Limit – Application Rules	79
Traffic Management During Construction	80
Choices for Traffic Control Devices	81
General Sign Arrangement During Construction	83
Blackspot Definition	84
New Ranking System for Blackspots	85
Accident Prevention – Road Safety Audit	86
Road Safety Audit Stage 1 & 2	87
Road Safety Audit Stage 3	88
Road Safety Audit Stage 4 (Part 1)	89
Road Safety Audit Stage 4 (Part 2 & Part 3)	90
Road Safety Audit Stage 5	91
Accident Reduction – Blackspot Eradication	92
Road Safety Auditor & Traffic Management Audit	93
Road Safety Officer, TMP and TMSR	94
Road Traffic	95
Road Traffic Volume Malaysia (RTVM)	97
Traffic Census and Vehicle Classification	98
Registered Vehicles and Drivers	99
Average Daily Traffic (ADT) at 63 Locations, Peninsular Malaysia, 2010 – 2014	100
Types of Traffic Survey	104
Road Survey and Land Acquisition	105
Land Survey for Roadworks	107
Guidelines on Land Acquisition Process	109
Organisation's Roles in the Land Acquisition Process	110
Guidelines for Preparation of Payment	111
Road Design Standards	113
Highway Planning and Design	115
Road Classification and Hierarchy	117
Access Control	118
Level of Service	119
Design Level of Service and V/C Ratio	120
Capacity Analysis and P.C.U	121

Content

Design Vehicles 122
Turning Characteristics of Design Vehicles 123
Cross – Sectional Elements 124
Roadside Clear Zone 126
Selection of Design Standard for Roads 127
Design Speed for Roads in Rural and Urban Areas 128
Summary on Geometric Design Criteria for Roads in Rural Area 129
Summary on Geometric Design Criteria for Roads in Urban Area 130
Horizontal Alignment 131
Vertical Alignment 133
Vertical K – Values and Max/ Min Grades 134
Maximum Grade for Roads in Rural Area 135
Maximum Grade for Roads in Urban Area 136
Critical Grade Length 137
Climbing Lane 138
Passing/ Overtaking Lane 139
Types of Passing/ Overtaking Lane 140
Warrant Criteria for Motorcycle Lane 141
Sight Distances and Approach Stopping Sight Distances (ASD) 142
Decision Sight Distance 143
ASD, ESD and SISD 144
Passing Sight Distances 145
Driver's Reaction Time 146
Pedestrian Facilities 147
Road Safety Barriers 149
Longitudinal Safety Barriers and NCHRP 350 Test Level 151
Warrants for Installation of Safety Barriers 152
Typical W-Beam Guardrail Barrier 153
Typical Thrie Beam Guardrail 155
Typical Wire Rope Safety Barrier 156
New Jersey Barrier 810 (Reinforced) 157
New Jersey Barrier 1070 (Reinforced) 158
New Jersey Barrier Ramped Terminal Treatment (810mm & 1070mm) 159
Treatment of Guardrail at Bridge Parapet 160
Types of Safety Barrier based on Test Level 161
Criteria for High Risk Locations 162
Comparing Barrier Test Level Standards 163
Impact Severity Level and Occupancy Risk 164
Road Intersection Design 165
Traffic Signal Control 167
Traffic Signal 168
Selection of Intersection Type 169
Design Vehicles and Spacing of Intersection 170
Provision of Right Turn Lane and U-Turn Facilities 171
Length of Deceleration Lane 172

Content

Length of Acceleration Lane 173
Determination of Interchange Type 174
Type of Intersecting Facility and Design Elements 175
Minimum Acceleration and Deceleration Lengths for Interchange Terminals 176
Pavement Design 177
Pavement Design 179
Flexible Pavement 181
Properties of Pavement Layers 182
Pavement Design Procedure 183
Flexible Pavement Structure 184
Catalogue of Pavement Structures 185
Design of Special Pavement Structures 186
Rigid Pavement 187
Types of Joint in Rigid Pavement 188
Specialty Mixes and Surface Treatments 189
Pavement Evaluation 191
Traffic Signs and Markings 195
About Road Traffic Signs 197
Classification and Design of Traffic Signs 198
Effective Traffic Signs 199
Shape and Size s of Traffic Signs 201
Colour of Traffic Signs 202
Clearance and Placement of Traffic Signs 203
Distance, Destination and Directional Signs 204
Road Markings 205
Road Lighting 207
Introduction to Road Lighting 209
Need for Road Lighting 210
Warrant Analysis for Lighting of Midblock 211
Warrant Analysis for Lighting of Intersection 212
Lighting Classes by Classification of Roads 213
Lighting for Other Facilities 214
Traffic Impact Assessment 215
Scope & Process of TIA 217
Criteria, Trigger Levels & LOS 218
Guidelines for Performing TIA 219
Trip Generation 220
Trip Distribution 221
Trip Assignment 222
Projection Year 223
Mitigation and Reporting 224
Drainage Design 225
Hydrology 227
Hydrology (Design Procedure) 228
Surface Drainage 229

Content

Component of Surface Drainage 230
Culvert 231
Subsoil Drainage 232
Bridge Design 233
Backgrounds 235
Classification of Bridges 236
Type of Bridges 237
Bridge System 238
Components of a Bridge 239
Superstructure 240
Substructure 242
Loading on Bridges 244
Aspect of Hydrology in Bridge Design 245
Geotechnical 247
Geotechnical Standard & Specifications 249
Some Typical Geotechnical Design Criteria for Road Works 250
Slope Profile and Geometry 252
Specifications on Earthworks 253
Stability & Settlement Problems 254
Types of Treatment on Soft Ground Problems 254
Common Solutions for Stability Problems 255
Method of Stabilizing Rock Slopes 259
Site Investigation (SI) 260
Method of Exploration 261
JKR Probe or Macintosh Probe 262
Deep Boring 264
List of Technical Documents 267
Standard Specifications Published by Cawangan Jalan JKRArahan Teknik (Jalan) Published by Cawangan 269
Guidelines Published by Cawangan Jalan JKR 270
Standard Drawings Published by Cawangan Jalan JKR 271
Jalan JKR 272

ABOUT MALAYSIA

About Malaysia

Malaysia in South East Asia

A part of Malaysia lies at the south eastern tip of the Asia Continent and the other part lies within the Malay Archipelago.

Malay Archipelago is the world's largest group of islands, situated between mainland Asia and Australia. Other countries lying wholly or partly within the archipelago are Indonesia and the Philippines.

About Malaysia

The State in Malaysia

Table A1: State flags in accordance with the official order of hierarchy

Flag	Name	Capital	Pop (2013*)	Area (km^2)
	Malaysia	Kuala Lumpur	29,915,300	329,845
	Kedah	Alor Setar	2,030,300	9,426
	Pahang	Kuantan	1,564,400	35,964
	Perak	Ipoh	2,443,000	21,006
	Perlis	Kangar	242,100	810
	Selangor	Shah Alam	5,796,200	7,956
	Negeri Sembilan	Seremban	1,069,600	6,645
	Johor	Johor Bahru	3,493,700	19,984
	Kelantan	Kota Bharu	1,681,900	14,922
	Terengganu	Kuala Terengganu	1,110,100	12,955
	Sarawak	Kuching	2,608,100	124,450
	Pulau Pinang	George Town	1,645,000	1,046
	Melaka	Bandar Melaka	852,000	1,650
	Sabah	Kota Kinabalu	3,489,600	76,115
	Federal Territory of Kuala Lumpur	Kuala Lumpur	1,717,300	243
	Federal Territory of Labuan	Bandar Labuan	91,600	92
	Federal Territory of Putrajaya		80,500	46

There are a total of 13 states and 3 federal territories in Malaysia. Two states (Sabah and Sarawak) and one federal territory (Labuan) are located in East Malaysia while the rest are in Peninsular Malaysia. The table below presents the State flags in accordance with the official order of hierarchy.

Note: (*) Preliminary figures
Source: Malaysia Statistic Department

About Malaysia

History In Brief

Malaysia has its origins in the Malay Kingdoms that originated in the South East Asia region. In the 18th century, it became a colony of the British Empire and were known as the Straits Settlements. Peninsular Malaysia, then known as Malaya, was first unified under the Commonwealth in 1946, before becoming the Federation of Malaya in 1948. It then got its independence on the 31th August 1957. In 16th September 1963, Malaysia was formed which included Sabah, Sarawak and Singapore. However, Singapore left the Federation in 9th August 1965 to become an independent city state.

Today, Malaysia is divided into 13 states (*Negeri*) and 3 federal territories (*Wilayah Persekutuan*). 11 states and 2 federal territories are in Peninsula Malaysia, the other 2 states and 1 federal territory are in East Malaysia. As Malaysia is a federation, the governance of the states is divided between the federal and the state governments, while the Federal government has direct administration of the federal territories.

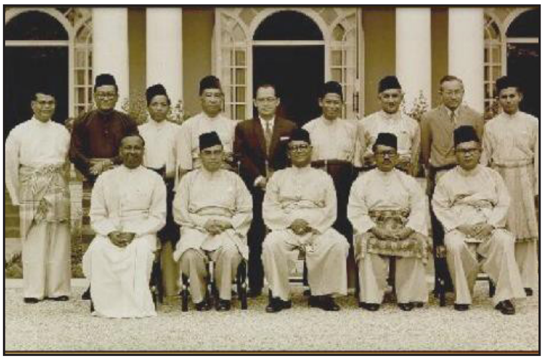
The 13 states are based on historical Malay Kingdoms, and each state is further divided into districts (*daerah or jajahan* in Kelantan), which are then divided into mukim. Nine of the thirteen states, known as the Malay States, retained their royal families.

The Federal King (titled Yang di-Pertuan Agong) is elected (de facto rotated) among the nine rulers to serve a 5-year term. Each state has a unicameral legislature called Dewan Undangan Negeri. The states of East Malaysia (Sabah and Sarawak) have separate immigration policies and controls and a unique residency status.

The Parliament of Malaysia is permitted to legislate on issues of land, Islamic religion and local government in order to provide for a uniform law between different states, or on the request of the state assembly concerned. The law in question must also be passed by the state assembly as well, except in the case of certain land law-related subjects. Non-Islamic issues that fall under the purview of the state may also be legislated on at the federal level for the purpose of conforming with Malaysian treaty obligations.

Since its independence, Malaysia has had one of the best economic records in Asia, with GDP growing an average 6.5% for the first 50 years of independence. The economy of the country has, traditionally, been propelled by its natural resources, but is now expanding in the industrial, commerce and tourism sectors.

Declaration of Independence



The 1st Cabinet of Malaya

About Malaysia

Basic Facts

Capital: Kuala Lumpur 3°08'N 101°42'E
Federal Gov. Administration Centre: Wilayah Persekutuan Putrajaya

Official language: Malay - the current terminology as per government policy is *Bahasa Malaysia* but legislation continues to refer to the official language as *Bahasa Melayu*. *English* may continue to be used for some official purposes under the National Language Act 1967.

Official Religion: Islam
Demonym: Malaysian
Ethnic groups: 50.1% Malay, 22.5% Chinese, 6.7 % Indians, 11.7%
Other Bumiputera, 0.8% Others, 8.1 % Non-Malaysian Citizens

Government: Federal constitutional elective monarchy and Parliamentary democracy
Yang di-Pertuan Agong: Seri Paduka Baginda Yang di-Pertuan Agong Almu'tasimu Billahi Muhibbuddin Tuanku Alhaj Abdul Halim Mu'adzam Shah ibni Almarhum Sultan Badlishah

Prime Minister: Dato' Sri Mohd Najib Tun Abdul Razak

Climate: Tropical climate with warm and humid weather all year round. Temperatures range from 21°C to 32°C. Annual rainfall varies from 2000 mm to 2500 mm.

Monsoon Winds Seasons:

Southwest Monsoon - late May to September
Northeast Monsoon - November to March

The Northeast Monsoon brings in more rainfall compared to the Southwest Monsoon.

Currency: Ringgit (RM) or (MYR)

Population:

	2013 (projection)	29,915,300
	2010 census	28,588,600
	2005 census	25,347,368
	2000 census	24,821,286
	Density	85.8 per km^2

Malaysia is the **43rd** most populated country in the world.

Total Area: 329,845 km^2 (water 0.37%) Malaysia is the **66th** largest country by total land area in the world.
Total Land Borders: 3,147.3 km

Thailand: 646.5 km
Indonesia: 2,019.5 km
Brunei: 481.3 km

Highest Point: Mount Kinabalu (4,095 m)
Lowest Point: Indian Ocean (0 m)
Longest River: Rajang River, Sarawak (563 km)
Total Coastline: 4,675 km
Peninsular Malaysia: 2,068 km
East Malaysia: 2,607 km

Malaysia has the **29th** longest coastline in the world.

Land Use: Large areas of land are used as palm oil plantations, rubber plantations, and paddy fields. Malaysia is the largest exporter of palm oil in the world producing 15.8 million tonnes of crude palm oil in 2007. In 2001 the percentage arable land in Malaysia is 5.5%. Croplands consists of 17.6%, and pasture 0.9%. Forests covers 58% while other land uses consists of 17%. In 1998, irrigated land covers 2,941 km^2.

Time zone: MST (UTC+8)
Drives on the: Left

About Malaysia

Gross Domestic Product

GDP is the value of total production of goods and services in a country over a specified period, typically a year. How much GDP grows from one period to the next is an indication of a country's economic health. The first chart shows the GDP of Malaysia till 2014. While the second chart compares the GDP of a number of countries in Asia.

Gross Domestic Product
GDP in current U.S. dollars
Not adjusted inflation

Malaysia
$312.45 Billion
2014

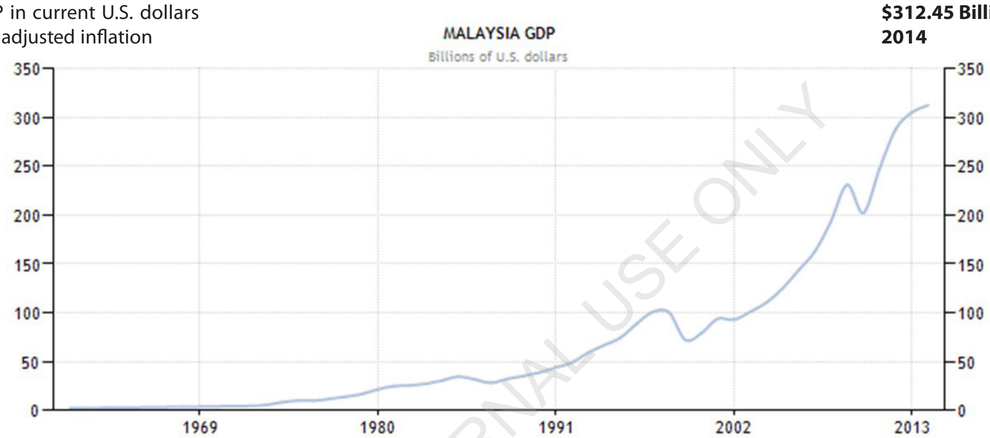


Figure A1: GDP of Malaysia till 2014
Source: World Bank, World Development Indicators December, 2014

Gross Domestic Product
GDP in current U.S. dollars
Not adjusted inflation

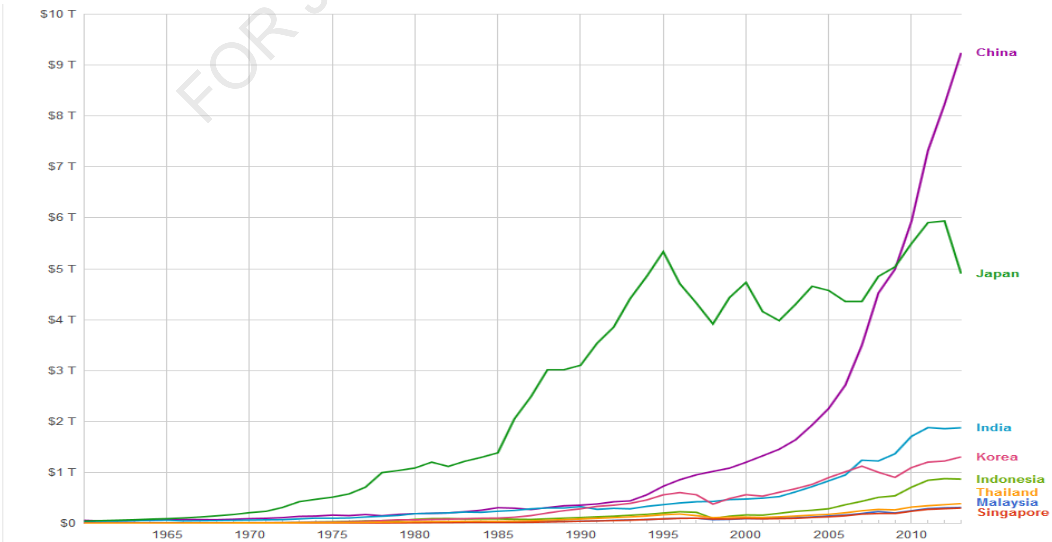


Figure A2: GDP of a number of countries in the Asia
Source: World Bank, World Development Indicators December, 2014

About Malaysia

Key Indicators on Economy and Transportation

Table A2: Malaysia's Key Indicators

	2013	2014
GDP at current prices (RM million)	1,018,821e	1,106,580p
GDP Growth (%)	4.7e	6.0p
Per capita income	RM33,010e	-
Inflation rate (CPI)	2.0-3.0%e	-
Labour force ('000)	13,634.6	13,931.6
Unemployment rate (%)	3.1	2.9
Total export (f.o.b.) (RM million)	719,992.4	766,128.5
Total import (c.i.f.) (RM million)	648,694.9	682,982.4
Major exports	Foods Beverages and Tobacco Crude Materials, Inedible Mineral Fuels, Lubricants, and Other Oils & Animal and Vegetable fats Materials Chemistry Manufactured Goods (including tin) Machinery and Transport Equipment Miscellaneous Manufactured Articles Miscellaneous Transactions and Commodities	
Major imports	Foods Beverages and Tobacco Crude Materials, Inedible Mineral Fuels, Lubricants, and Other Oils & Animal and Vegetable fats Materials Chemistry Manufactured Goods (including tin) Machinery and Transport Equipment Miscellaneous Manufactured Articles Miscellaneous Transactions and Commodities	

Table A3: Malaysia's Road Statistics

Data for 2013:

• Expressway (km) (9.4%)	1,837.20
• Federal roads (km)	19,461.79
• State roads (km)	184,708.34
• Total Road Network (km)	206,007.33
• Population (2013)	29,915,300
• Road density (km/km^2)	0.6
• Passenger cars	10,335,037
• Cars per 1,000 pop.	345
• Motor vehicles / km of road	53
• Motor vehicles	10,926,125
• Vehicles per 1,000 pop.	365
• Road accidents	477,204
• Accident per 100,000 pop.	1595.18
• Road fatalities	19,900
• Fatal per 100,000 pop.	66.52
• Total road maintenance cost for road	RM 3.57 Bill

Source: Statistik Jalan Edisi 2014 - Cawangan Senggara Fasiliti Jalan JKR, Malaysia Statistic Department & PDRM 2014)

Notes:
p Preliminary.
e Estimate.

Source: Economic Planning Unit, Prime Minister's Department/Malaysia Statistic Department

About Malaysia

Key Indicators in Demography

The table below is a demography of the Malaysia's population (by states) which is a projection for 2013. The actual figures for the recent year are currently not available (Note: Sex Ratio - male per 100 female; Death Rate - per 1000 population)

Table A3**:** Demography Of The Malaysia's Population By States (A Projection For 2013)

State	Population	Annual Population Growth Rate	Age Group (%)			Dependency Ratio			Sex Ratio	Life Expectancy at Birth		Total Fertility Ratee	Crude Birth Ratee	Crude Death Ratee	Infant Mortality Ratee	Still Birth Ratee
			0 - 14	15 - 64	65+	Total	Young Age	Old Age		Male	Female					
MALAYSIA	29,915,300	1.4	26.0	68.5	5.5	45.9	37.9	8.0	106	72.5	77.1	2.1	17.2	4.7	6.6	4.6
Johor	3,493,700	1.2	25.7	68.5	5.8	46.1	37.6	8.5	112	72.1	76.8	2.1	16.6	4.9	6.6	4.3
Kedah	2,030,300	1.4	27.2	66.2	6.6	51.1	41.1	9.9	103	70.3	76.1	2.6	17.8	6.2	7.5	5.3
Kelantan	1,681,900	1.9	31.9	62.3	5.8	60.5	51.2	9.3	101	69.2	75.3	3.6	22.4	6.3	8.0	6.1
Melaka	852,00	1.0	24.6	68.6	6.8	45.9	35.9	10.0	102	71.8	76.9	2.1	16.1	5.5	8.9	5.0
Negeri Sembilan	1,069,600	1.1	25.3	68.4	6.3	46.1	37.0	9.1	108	71.0	76.4	2.2	16.3	5.7	7.5	4.8
Pahang	1,564,400	1.1	27.9	66.4	5.7	50.6	42.0	8.5	114	70.4	76.1	2.4	17.1	5.2	8.7	5.5
Perak	2,443,000	0.7	25.0	66.5	8.5	50.3	37.6	12.8	103	71.1	77.0	2.3	15.2	6.6	6.3	4.6
Perlis	242,100	1.1	25.0	67.2	7.8	48.8	37.2	11.5	98	70.6	75.7	2.6	17.5	7.2	8.8	5.7
Pulau Pinang	1,645,000	1.3	21.6	71.3	7.1	40.2	30.3	9.9	101	72.4	77.5	1.6	13.5	5.9	7.7	4.3
Sabah	3,489,600	1.6	26.5	70.4	3.1	42.0	37.7	4.3	109	-	-	..	..	..	..	..
Sarawak	2,608,100	1.5	27.1	66.8	6.1	49.6	40.5	9.1	108	74.6	78.2	2.1	16.5	4.2	6.5	4.5
Selangor1	5,796,200	1.6	24.6	71.3	4.1	40.3	34.5	5.8	108	73.3	77.4	2.0	18.5	3.5	5.6	3.7
Terengganu	1,110,100	1.5	32.0	63.0	5.0	58.7	50.8	8.0	104	68.5	74.5	3.4	22.7	5.6	8.7	6.5
WP Kuala Lumpur	1,717,300	0.9	21.5	73.2	5.3	36.5	29.3	7.2	104	74.0	78.0	1.6	15.2	4.0	5.8	4.3
WP Labuan	91,600	1.1	28.6	68.6	2.8	45.7	41.7	4.0	103	-	-	2.0	19.1	2.8	9.2	4.0
WP Putrajaya	80,500	2.7	36.5	62.7	0.8	59.4	58.1	1.3	90	-	-	2.9	41.1	1.6	8.2	2.8

Source: Malaysia Statistic Department

Note:

1. Mid-Year Population Estimates based on the Population and Housing Census of Malaysia 2010.
2. p Preliminary figures
3. The added total may differ due to rounding
4. e Estimates figures
5. 1 Includes W.P. Putrajaya
6. .. Data for Sabah is not published due to under registration
7. The age structure of a population affects a nation's key socioeconomic issues, e.g. investment in health for older populations and investment in education for young populations.

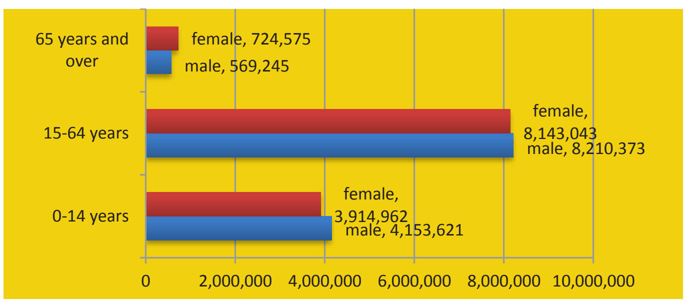


Figure A3: Distribution of the Population by Age Group

Source: CIA World Factbook (2008)

ROAD INFRASTRUCTURE

Road Infrastructure

Road Construction in Malaysia

In Malaysia, road constructions has begun since before independence. Before 1957, there has been a road system linking Johor Bahru in the south with Kangar in the north and Kota Bharu in the East Coast, connecting main cities between the other cities. After the country gained independence in 1957, efforts to improve the road system has been done systematically through the rapid development planning under the 5 years Malaysia Plan launched by the Federal Government.

Roads in Malaysia are classified in 2 broad categories, namely Federal roads and State roads. The construction of these roads are implemented by the Federal Government and State Government respectively. In the late 1980s, the government started the construction of toll expressways through private concession companies which are then authorized to collect toll charges from the road users. Network of toll expressways are an alternative to the existing road network and are built with various services and facilities for the users.

Road Administrators in Malaysia:

- Toll Expressways: under the administration of the Malaysia Highway Authority (Lembaga Lebuhraya Malaysia). Technically, this category of road is also considered as the Federal roads but administered by a special highway authority.
- Federal Roads: under the administration of the Public Works Department Malaysia (PWD) with the cooperation and assistance of all the State and District PWDs.
- State Roads: under the administration of the State and District PWDs.
- Municipal Roads: under the administration of the District Municipal

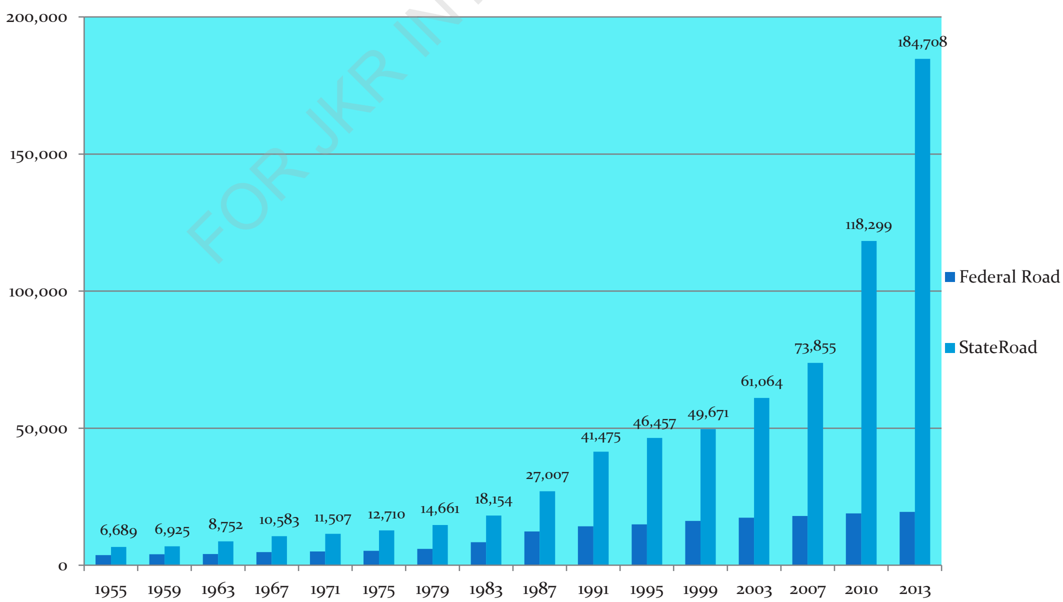


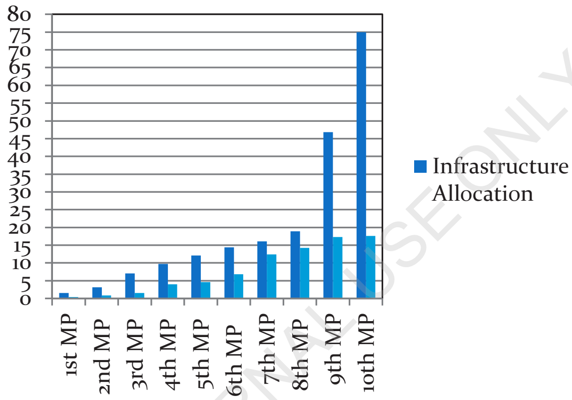
Figure B1: Development of Road Network based on the total road length (Federal and State roads) from 1955 to 2013
Source: Road Statistic 2014, BSFJ, Caw. Kejuruteraan Senggara, IP JKR Malaysia

Road Infrastructure

Expenditure on Road Development

Malaysia's 5-year national development plans incorporated road development as one of the important elements for the overall economic and social development of the country. The table below depicts the growth in the expenditure on road development plans under each consecutive 5-year Malaysia Plan which was formulated from 1966 to 2015.

Figure B2: Allocation for Development



Source: Road Infrastructure Development in Malaysia

Table B1: Malaysia's Expenditure on Road Development

Plan	Period	Infrastructure Allocation (RM Billion)	Road Development Allocation (RM Billion)	Road/Infra (% allocation)
1st Malaysia	1966 - 1970	1.55	0.4	25
2nd Malaysia	1971 - 1975	3.15	0.8	25
3rd Malaysia	1976 - 1980	7.0	1.55	22
4th Malaysia	1981 - 1985	9.7	4.0	41
5th Malaysia	1986 - 1990	12.1	4.6	38
6th Malaysia	1991 - 1995	14.4	6.8	47
7th Malaysia	1996 - 2000	16.1	12.4	77
8th Malaysia	2001 - 2005	18.9	14.2	75
9th Malaysia	2006 - 2010	46.8	17.3	36
10th Malaysia	2011 - 2015	75.0	17.6	24

Road Infrastructure

Malaysia Road Development Index and Service Level

The majority of the existing road network is a culmination from numerous upgrading and rehabilitation exercises on what were formerly bridle paths. These roads initially meander about hilly terrains, or cut through traditional settlements that have now transformed into busy towns. On certain stretches, the roads even bisect the railway lines. As the number of registered vehicles soared from just over 1.5 million in 1976 to almost 20 million today, more and more of these roads have exceeded their volumetric capacities.

The road development level is a measure of the quantity of road length per unit area. Table B2 below shows the road development level between the states in Malaysia and the comparison with other developing countries. The increase in road length under several Malaysia Plan have resulted in significant improvement of the Road Development Index from 0.74 in 1995 to 1.05 in 2013.

Figure B3: Malaysia Road Development Index

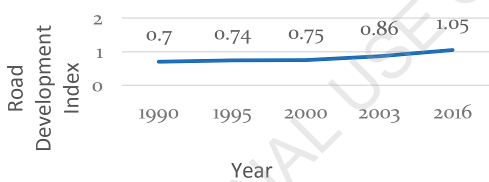


Table B2 : Development in Malaysia to Comparison With Other Developing Countries

Country	Area	Population ($x10^3$)	Road Length	Road Development Index	Road Density Level	Road Service Level (km/population)
USA	9,826	310,232	6,465,799	3.70	0.66	20.84
Germany	357	82,282	644,480	3.76	1.81	7.83
UK	243	61,284	398,366	3.26	1.64	6.50
France	551	62,814	1,027,183	5.52	1.86	16.35
Italy	301	58,090	487,700	3.69	1.62	8.40
Japan	377	126,804	1,203,777	5.51	3.19	9.49
Indonesia	1,905	242,968	437,759	0.64	0.23	1.80
Thailand	513	66,404	180,053	0.98	0.35	2.71
Singapore	0.70	4,701	3,325	1.84	4.77	0.71
Vietnam	331	89,571	222,179	1.29	0.67	2.48
Malaysia	329,845	29,915	100,002	1.05	0.30	3.63

Source:
(i) Statistik Jalan 2014, Bahagian Senggara Jalan, Cawangan Kejuruteraan Senggara, IP JKR Malaysia
(ii) World Road Statistic, 2009
(iii) CIA, The World Factbook

ROAD NETWORK

Road Network

Malaysia Road Network

In 2014, there are about 204,000 kilometres of road in Malaysia, 76% of which are paved. This network can be broadly categorised into the Federal and State roads. Federal Roads are all roads declared under the Federal Roads Ordinance (1959). This category of road includes the National Expressway and Highways under the administration of Malaysia Highway Authority (MHA). The Federal PWD manages about 17,700 kilometres of Federal Roads while the state PWDs manage another 184,000 kilometres of the State roads. Another 1,996 km of the Federal road network (1,996 km) is under the jurisdiction of the Malaysian Highway Authority.

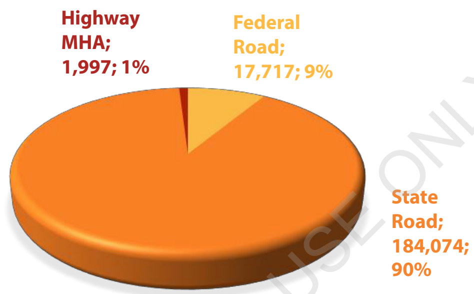


Figure C1: Distribution of Road Network - Based on length by road authorities (2013)

Table C1 : Road Length in Malaysia Based on Year and Paved Condition

End of	FEDERAL ROAD			STATE ROAD			TOTAL LENGTH		
Year	Paved	Unpaved	Total	Paved	Unpaved	Total	Paved	Unpaved	Total
2000	15,920.50	855.42	16,775.92	35,845.39	14,969.15	50,814.54	51,765.89	15,824.57	67,590.46
2001	16,001.08	855.42	16,856.50	41,135.32	15,025.76	56,161.08	57,136.40	15,881.18	73,017.58
2002	16,128.53	855.42	16,983.95	41,457.35	14,961.68	56,419.03	57,585.88	15,817.10	73,402.98
2003	16,461.09	908.18	17,369.27	44,285.08	16,778.99	61,064.07	60,746.17	17,687.17	78,433.34
2004	17,737.86	356.99	18,094.85	43,337.47	18,082.85	61,420.32	61,075.32	18,439.84	79,515.16
2005	17,451.75	313.18	17,764.93	51,888.69	18,860.87	70,749.56	69,340.44	19,174.05	88,514.49
2006	17,508.80	256.18	17,764.98	55,272.55	18,582.07	73,854.62	72,781.35	18,838.25	91,619.60
2007	17,781.44	257.18	18,037.62	55,272.55	18,582.07	73,854.62	73,053.99	18,839.25	91,893.24
2008	18,146.37	10.40	18,156.77	55,272.58	18,582.12	73,854.70	73,418.95	18,592.52	92,011.47
2009	18,307.00	10.40	18,317.40	81,432.12	24,642.99	106,075.12	100,002.45	24,653.39	92,011.47
2010	18,920.07	0.00	18,920.07	92,457.46	25,841.86	118,299.42	111,377.96	25,841.96	124,219.49
2011	19,216.24	0.00	19,216.24	108,300.72	29,650.26	137,950.98	127,516.96	29,650.26	157,167.22
2012	19,427.51	0.00	19,427.51	123,584.82	39,686.97	163,271.79	143,012.33	39,686.97	182,699.30
2013	19,461.79	0.00	19,461.79	138,543.39	46,164.95	184,708.34	158,005.17	46,164.95	204,170.12
2014	19,717.22	0.00	19,717.22	134,979.44	49,094.36	184,073.80	154,696.66	49,094.36	203,791.02

Source: Road Statistics 2014

Road Network

Federal Road System

Malaysian Federal Roads System (*Sistem Laluan Persekutuan Malaysia*), is the main national road network in Malaysia. All federal roads in Malaysia are under the purview of Ministry of Works (MoW). According to Minister's Function Act 1969, MoW is responsible to plan, build and maintain all federal roads gazette under the Federal Road Act 1959. However, most of the Federal road projects were built and maintained by the Public Works Department Malaysia which is one of the implementing agency under the MoW (with exception of Sabah and Sarawak, whereby PWD in these two states is under respective state government).

Most of the federal roads in Peninsular Malaysia were built during the British colonial era before 1957. At that time, the British government built the roads in order to enable them to transport goods and commodities easier.

In Sabah, most of the federal roads were built during the occupation of British North Borneo under North Borneo Chartered Company administration, and unlike most federal roads in Peninsular Malaysia which uses only numbers to label federal roads, Sabah federal road codes begin with the letter A followed by route number.

However, in Sarawak, no road network system was developed during the rule of White Rajah Brooke dynasty. As a result, right after Sarawak joined the Federation of Malaysia on 16 September 1963, the Federal Government of Malaysia began to built a road network system connecting Sarawak to Sabah, known as Pan Borneo Highway.

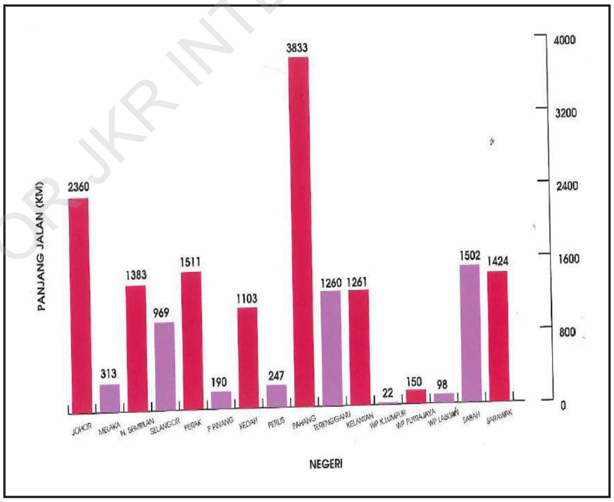


Figure C2: Distribution of Federal Road Network
Based on road length by states (2013) Source : Road Statistic 2014

Road Network

Category of Federal Road

Table C2: Category of Federal Road

FEDERAL ROAD CATEGORY	GENERAL DESCRIPTION	RESPONSIBLE AGENCY
Toll Expressways & Toll Highways	Inter-urban expressways and highways where toll are collected	Malaysia Highway Authority (MHA)
National Highways	Inter-urban highway linking Federal Capital, State Capitals and points of entry to / exit from the country	Federal PWD (include City Hall of Kuala Lumpur and Municipal Council of Labuan)
Regional Development	Roads forming the network within a region	Federal PWD Regional Development Area
Minor Roads (access to Federal Government Institutions)	Roads leading to and within Federal Government Institutions	Federal PWD and State PWDs

Apart from the Toll Expressways or Toll Highways, the other roads under the Federal Road category can be sub-categorised into several types which are as follows:

Main Federal Roads
Mostly found at Peninsular Malaysia, Sabah and Sarawak.

FELDA/FELCRA Federal Roads
Mostly found at FELDA and FELCRA settlements in Peninsula Malaysia only. The road was built by FELDA or FELCRA and JKR. In Sarawak, federal roads for FELDA is in Lundu and for SALCRA is in Sarikei.

Industrial Federal Roads
Mostly found at the industrial areas in Peninsular Malaysia only.
In Sarawak, there are two industrial federal roads, which are located at Pending Industrial Estate in Kuching and Kidurong Industrial Estate in Bintulu.

Institutional Facilities Federal Roads
Mostly found at the entrance to the federal institutional facilities such as university, military bases, satellite earth stations, airports, TV and radio frequency stations, telecom exchange stations, hospitals and tourist attractions.

Road Network

Numbering System for Federal Road

Table C3 Notes : MoW - Ministry of Works; PWD - Public Works Department; MHA - Malaysia Highway Authority

No	Examples	Road Number	Authorized Agency
1	Federal Road	1 - 221	MoW /PWD
2	Federal Road - FELDA	1000 - 2748	MoW /PWD
3	Road to Main Federal Institution	250 - 479	MoW /PWD
4	Industrial Federal Road	3000 - 3740	MoW /PWD
5	Main Federal Road in Labuan	700 - 799	MoW /PWD
6	Main Federal Road in Sabah	A01 - A99	MoW /PWD Sabah
7	Main Federal Road in Sarawak	1-1 - 1-59 3-1 - 3-99	MoW /PWD Sarawak
8	Tolled Expressway	E1 - E30	MoW /MHA /Concession Companies

Road Network

Toll Expressways

The Malaysian Highway Authority (MHA) is responsible for supervising and executing the design, construction, regulation, operation and maintenance of inter-urban highways in Malaysia. These comfortable expressways link all major townships and potential development areas, and have catalysed industrial growth by enabling efficient transportation.

Today, the North-South Expressway together with the Penang Bridge and the Kuala Lumpur - Karak Highway form the backbone of Malaysia's road infrastructure, contributing to the country's rapid socio-economic development.

The country's successful privatisation programme coupled with its strong economic growth has also induced more highway development projects in the last few years. Now, there are 30 toll expressways in operation, each being operated and maintained by a private concessionaire.

Road Network

List of Toll Expressways and Concessionaire

Table C4(i)

No.	Toll Expressway	Highway Shield	Connects	Length (km)	Consessionaire Company
1	North-South Expressway (NSE Northern Route)	E1	Bukit Kayu Hitam - Bukit Lanjan	460	**PLUS Malaysia** with its subsidiary **Projek Lebuhraya Usahasama Berhad**
2	New Klang Valley Expressway (NKVE)	E1	Bukit Raja - Jalan Duta	35	**PLUS Malaysia** with its subsidiary **Projek Lebuhraya Usahasama Berhad**
3	North-South Expressway (NSE Southern Route)	E2	Sg Besi - Pandan (Johor)	312	**PLUS Malaysia** with its subsidiary **Projek Lebuhraya Usahasama Berhad**
4	Second Link Expressway (Link Kedua) inc. Malaysia - Singapore Second Link (MSSC)	E3	a. Senai Link b. Main Link c. Pontian Link d. Johor Bahru Parkway	44	**PLUS Malaysia** with its subsidiary **Projek Lebuhraya Usahasama Berhad**
5	Shah Alam Expressway (SAE/KESAS)	E5	Klang - Kuala Lumpur	34.5	Konsortium Expressway Shah Alam
6	North-South Expressway Central Link (termasuk Putrajaya Link)	E6	**Main Link:** Shah Alam - Nilai North **Putrajaya Link** : Putrajaya Interchange -Putrajaya	60	**PLUS Malaysia** with its subsidiary **Projek Lebuhraya Usahasama Berhad**
7	Cheras - Kajang Expressway (CKE/Grand Saga) (part of Federal Route 1)	E7	Cheras - Kajang	11.7	Grand Saga Berhad
8	Kuala Lumpur - Karak Expressway (part of Federal Route 2)	E8	Gombak - Karak	60	ANIH Berhad (Formerly known as MTD Prime Sdn Bhd)
9	East Coast Expressway (ECE/LPT)	E8	Karak - Kuala Terengganu	358	ANIH Berhad (Formerly known as MTD Prime Sdn Bhd)
10	Besraya Expressway	E9	**Main Link** : UPM Interchange - MRR2 **Eastern Extension Link:** Shamelin - Pandan Indah	28.3	Besraya Sdn Bhd
11	New Pantai Expressway (NPE) - inc. NPE Extension Expressway	E10	Subang Jaya - Bangsar	19.6	New Pantai Expressway Sdn Bhd
12	Damansara - Puchong Expressway (LDP)	E11	Damansara - Puchong	40	Lingkaran Trans Kota Holdings Berhad (LITRAK)

Road Network

List of Toll Expressways and Concessionaire

Table C4(ii)

No.	Toll Expressway	Highway Shield	Connects	Length (km)	Consessionaire Company
13	Ampang-Kuala Lumpur Elevated Highway (AKLEH)	E12	Kuala Lumpur - Ampang	7.9	Prolintas with its subsidiary Projek Lintasan Kota Sdn Bhd (AKLEH)
14	Kemuning - Shah Alam Highway (LKSA)	E13	Kemuning - Shah Alam	14.7	Prolintas with subsidiary Projek Lintasan Kota Sdn Bhd (AKLEH)
15	Johor Bahru Eastern Dispersal Link Expressway (EDL)	E14	Pandan - CIQ Sultan Iskandar	8.1	MRCB Lingkaran Selatan Sdn Bhd
16	Butterworth-Kulim Expressway (BKE)	E15	Butterworth - Kulim	17	PLUS Malaysia Berhad with its subsidiary Projek Lebuhraya Usahasama Berhad
17	Butterworth Outer Ring Road (BORR) (part of Federal Route 1)	E17	Around Butterworth Sungai Dua - Perai	14	Lingkaran Luar Butterworth Sdn Bhd (LLB)
18	Kajang Dispersal Link Expressway (SILK)	E18	Around Kajang Mines - UPM	37	Sistem Lingkaran-Lebuhraya Kajang Sdn Bhd (SILK)
19	Maju Expressway (MEX) (Kuala Lumpur - Putrajaya Expressway) (KLPE)	E20	Kuala Lumpur - Putrajaya	42	Maju Expressway Sdn Bhd (Formerly known as Konsortium Lapangan Terjaya Sdn Bhd (KLT)
20	Kajang-Seremban Highway (KASEH/LEKAS)	E21	Kajang - Seremban	44.3	Lebuhraya Kajang-Seremban Sdn. Bhd. (Lekas) (former concessionaries known as Kajang Seremban Highway Sdn Bhd (KASEH))
21	Senai-Desaru Expressway (SDE)	E22	Senai - Desaru	77	Senai-Desaru Expressway Berhad (SDEB)
22	Sprint Expressway (Kerinchi Link, Damansara Link and Penchala Link)		a. Western Dispersial Link b. Kerinchi Link Mont Kiara - Seputeh c. Damansara Link Kayu Ara - Jalan Duta-Semantan d. Penchala Link Penchala - Mont Kiara	26.5	Sistem Penyuraian Trafik KL Barat Sdn Bhd (Sprint)

Road Network

List of Toll Expressways and Concessionaire

Table C4(iii)

No.	Toll Expressway	Highway Shield	Connects	Length (km)	Concessionaire Company
23	Tun Salahuddin Bridge	E24	Petra Jaya - Tanah Puteh	4	Zecon Berhad
24	**LATAR Expressway** (Assam Jawa - Templer Park Highway	E25	Ijok - Templer's Park	32	LATAR, KL-Kuala Selangor Expressway Berhad (KLS)
25	South Klang Valley Expressway (SKVE)	E26	Uniten - Pulau Indah	51.7	SKVE Holdings Sdn Bhd
26	Sultan Abdul Halim Muadzam Shah Bridge (Penang Second Bridge)	E28	South Channel Batu Maung - Bandar Cassia	24	Jambatan Kedua Sdn Bhd (JKSB)
27	Seremban-Port Dickson Highway (SPDH)	E29	Seremban - Port Dickson	23	**PLUS Malaysia Berhad** with its subsidiary **Projek Lebuhraya Usahasama Berhad**
28	New North Klang Straits Bypass (NNKSB) (part of Federal Route 20)	E30	Sungai Rasau - Port Klang	17.5	Lebuhraya Shahpadu Sdn Bhd
29	West Coast Expressway (WCE)	E32	Taiping - Banting	233	West Coast Expressway * Under construction
30	Duta-Ulu Klang Expressway (DUKE) (including the DUKE Extension Expressway)	E33	**a. Duta - Sentul Pasar - Ulu Klang Link** Jalan Duta - Sentul Pasar - Ulu Klang **b. Greenwood - Sentul Pasar Link** (part of Federal Route 2) Greenwood - Sentul Pasar **c. DUKE Extension Expressway** **d. Sri Damansara Link** **e. Setapak Link** **f. Tun Razak Link**	18	Konsortium Expressway Timur Utara Kuala Lumpur (Kesturi)
31	Guthrie Corridor Expressway (GCE)	E35	Rawang - Shah Alam	25	Prolintas with its subsidiary Prolintas Expressways Sdn Bhd (PEX)

Road Network

List of Toll Expressways and Concessionaire

Table C4(iv)

No.	Toll Expressway	Highway Shield	Connects	Length (km)	Concessionaire Company
34	Penang Bridge	E36	Penang Island - Seberang Perai	13.5	PLUS Malaysia Berhad with its subsidiary Projek Lebuhraya Usahasama Berhad
35	East-West Link Expressway (Salak Expressway) Kuala Lumpur-Seremban Expressway	E37	**East-West Link Expressway:** Seputeh - Cheras **Kuala Lumpur-Seremban Expressway:** Kuala Lumpur - Sungai Besi	13 8	ANIH Berhad (Formerly known as MetaCorp Sdn Bhd)
36	Stormwater Management and Road Tunnel (SMART)	E38	**Main Tunnel:** Bulatan Kampung Pandan on Jalan Tun Razak (Kuala Lumpur Middle Ring Road) - Sungai Besi Airport on Kuala Lumpur-Seremban Expressway **Sultan Ismail Link Tunnel:** Imbi - Main Tunnel	4	Syarikat Mengurus Air Banjir dan Terowong Sdn Bhd (SMART)
39	Damansara-Shah Alam Elevated Expressway (DASH)	--	Puncak Perdana - Penchala	23	Prolintas with its subsidiary Projek Lintasan Damansara-Shah Alam Sdn Bhd (DASH)

Road Network

Numbers to call in Case of Emergency

Table C5

EXPRESSWAY	HOTLINE NUMBER
Lebuhraya Utara Selatan (PLUS)	1800-88-0000
Jambatan Pulau Pinang (PBSB)	1-300-1-300-03
Lebuhraya Utara Selatan Hubungan Tengah (ELITE)	04-50311153
Laluan Kedua Malaysia-Singapura (LINK)	07-2788000
Lebuhraya Kuala Lumpur-Karak (MTD)	09-2330100
Lebuhraya Kulim-Butterworth (KLBK)	04-3986969
Lebuhraya Seremban-Port Dickson (SPDH)	06-6323060
Lebuhraya Shah Alam (KESAS)	03-56337188
Lebuhraya Cheras-Kajang (Grand Saga)	03-90750505
Lebuhraya Damansara-Puchong (LITRAK)	03-56329222
Lebuhraya Sungai Besi (BESRAYA)	1-800-880-999
Lebuhraya Bertingkat Ampang (PROLINTAS)	03-42523122
Lebuhraya SPRINT	03-79602000
Lebuhraya Hubungan Timur Barat (Metramac)	03-91732020
Lebuhraya Shahpadu	03-33420564
Lebuhraya Pantai Baru (NPE)	1-300-881 010
Lebuhraya Sistem Lingkaran Kajang (SILK)	1-800-881977
Lebuhraya Pantai Timur-Fasa 1 (LPT1)	09-5479111
Lebuhraya Koridor Guthrie (GCE)	03-60385052
Lebuhraya KL - Putrajaya (MEX)	03-83159111

Road Network

State Road System

State roads generally comprises of primary roads providing intra- state travel between the district administrative centres. Other roads included in this category are the local and urban collector roads under the municipalities and minor roads within the villages and the rural inhabited areas under the District Offices. Roads within the Federal Territories of Kuala Lumpur, Putrajaya and the Island of Labuan which are not designated as Federal roads are also classified under this category.

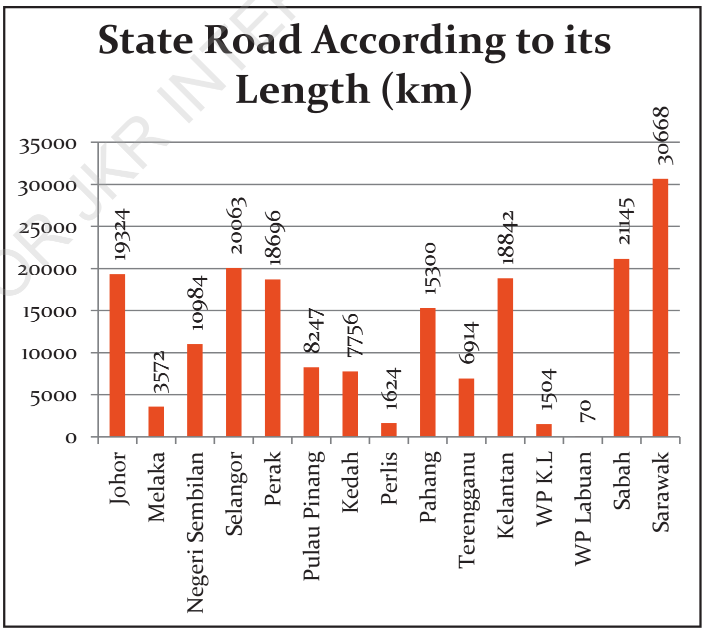


Figure C3: Distribution of State Road Network
Source: Road Statistics 2014

Road Network

Category of State Road and Numbering System

Table C6

STATE ROAD CATEGORY	GENERAL DESCRIPTION	RESPONSIBLE AGENCY
Roads within Federal Territories	Roads other than the designated Federal roads	City Hall of Kuala Lumpur and Municipal Council of Labuan
Primary Roads	Major roads forming the basic network within a district	State PWDs
Secondary Roads	Roads forming the network within a district	State PWDs
Minor Roads	Minor roads within a village or rural inhabited area	District Offices
Urban Collector Roads	Roads serving as collectors and distributors of traffic within a local authority area	Respective Local Authorities
Local Streets	Basic road network within an urban neighbourhood, serving primarily to offer direct access to abutting land	Respective Local Authorities
Arterial	This is a continuous road with partial access control for through traffic in urban areas	Respective Local Authorities

Table C7

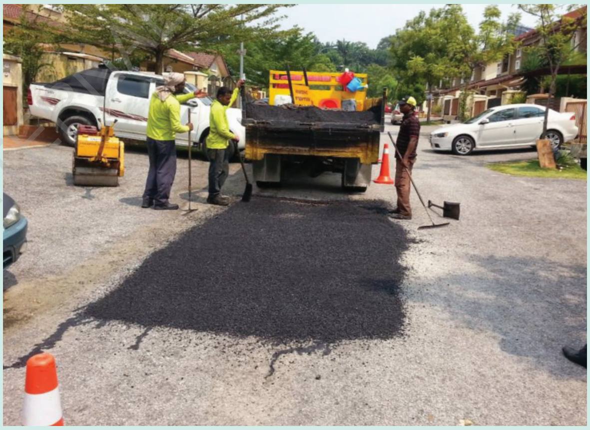
No.	State Road	Registration Plate of Peninsular Malaysia
1	Perak	A
2	Selangor	B
3	Pahang	C
4	Kelantan	D
5	Johor	J
6	Kedah	K
7	WP Labuan	L
8	Melaka	M

A6 D40 J55

Table C8

No.	State Road	Registration Plate of Peninsular Malaysia
9	Negeri Sembilan	N
10	Pulau Pinang	P
11	Perlis	R
12	Terengganu	T
13	WP Kuala Lumpur	W
14	Sabah	SA
15	Sarawak	Q

Road number for State Road starts with the alphabet of respective state followed with the number for the road.



ROAD MAINTENANCE

Road Maintenance

About Road Maintenance

Road Maintenance may be defined as 'all works of every description which are required for the preservation and sustenance of a road so as to prevent the deterioration of quality and efficiency to a noticeable extent below that which may affect its operational use'.

Purpose:
To preserve the road asset and serviceability by maintaining its physical conditions and operating functions at the best possible level in terms of User Costs, Safety, Comfort, Structural Adequacy and Aesthetics.

The activities and works that comprise road maintenance is open to variation and the definition of maintenance may vary from country to country.

Road maintenance concept is simple, but the management and organization is more complex. This is due to:

- Variations in size and type of activity.
- Relative urgencies of work.
- Geographic and seasonal variations.
- Definition of when work is needed.
- Relevant monitoring of work accomplished.

Maintenance needs are developed from a comparison of the existing condition of a road with standards established with respect to the current and future levels of service to be provided by that road.

Types of Maintenance:

- Routine Maintenance
- Periodic Maintenance
- Emergency Maintenance

Road Maintenance

Scope of Work for Routine Maintenance

Routine Maintenance:
Comprising normal daily repairs, replacements, correcting, cleaning and servicing which are bulk funded on an annual basis.

The works shall comprise of:

R01 - Pavement
- Patching of potholes
- Sealing of surface cracks

R02 - Maintenance of Road Shoulder
- Re-grading and clearance of vegetation
- Topping up of shoulders with suitable earth filling material
- Filling irregularities in unsealed shoulders
- Filling pavement/shoulder level differences

R03 – Grass Cutting
The grass shall be cut to a height of 50 mm.
- Road shoulder
- Slope area
- Berm drain, interceptor drain and all other types of drain on slopes
- Median

R04 - Maintenance of Road Furniture
- Cleaning of guardrails and barriers
- Cleaning of signs and posts
- Cleaning of kilometer posts and delineator post
- Cleaning of traffic signal aspects

Road Maintenance

Scope of Work for Routine Maintenance

R05 - Maintenance of Bridges and Culverts

- Cleaning of weep holes
- Cleaning of waterway or culvert opening and bridge carriageway
- Removal of vegetation

R06 - Road Marking

- Remarking poor paved road marker

R07 - Drainage

- Debris in lined drains
- Debris in unlined drains
- Debris in sumps
- Debris in culverts
- Blocked gratings

All routine maintenance works to be carried out based on either certain time cycle or max. percentage of road length per year according to the following categories of roads:

1. Protocol
2. Primary
3. Secondary
4. Minor

Road Maintenance

Scope of Work for Periodic Maintenance

Periodic Maintenance:
Individually funded works on pavements and structures identified and carried out at intervals exceeding one year, e.g. resurfacings, structure painting etc.

The works shall comprise of :

1. Preventive maintenance works
- Overlay
- Mill & Pave
- Hot in-Place Recycling (HIPR)

2. Pavement strengthening works
- Partial Reconstruction
- Reconstruction
- Leveling of Unpaved Shoulder
- Cold In-Place Recycling (CIPR)

3. Normal preventive maintenance works e.g. resurfacing works & other associated works

4. Non-pavement works within the R.O.W such as:
- Drains and culverts
- Road Furniture including road signs
- Structures
- Slopes

Road Maintenance

Scope of Work for Emergency Maintenance

Emergency Maintenance:

The works that require urgent intervention in a situation that causes disruption of traffic operation and/or may poses an immediate risk to life, property and environment such as

- Landslides, embankment failures & road subsidence
- Failure/collapse of bridges & related components
- Collapse of culverts and drainage structures
- Flooding
- Spillage of chemical, hazardous, toxic or
- Fallen trees

The works shall comprise of :

- Provide traffic management within one (1) hour
- Clearing of debris/materials
- Provide warning signs
- Construct temporary diversion/crossing
- To identify possible route diversion
- Closure of roads due to spillage of chemical, hazardous, toxic or
- Closure of roads due to fallen trees (within 2 hrs. after notification / detection)

Road Maintenance

Maintenance Concessionaires - Federal Roads

Before year 2000, the Malaysia's Federal roads were maintained by the Public Works Department. However, in the subsequent years the responsibility for the maintenance of the Federal road network was gradually contracted to a number of private concession companies. The concessionaires and their respective zone for maintenance work are based on the following regional position:

Table D1: Concessionaires And Their Respective Zone For Maintenance Work Are Based On The Following Regional Position

Regions	Company	Contact
Northen region (Peninsular Malaysia)	Belati Wangsa (M) Sdn Bhd	Tel: 05-2552211 Fax: 05-2414111 Emel: bwsb@belatiwangsa.com.my
Central and east coast region (Peninsular Malaysia)	Roadcare (M) Sdn Bhd	Tel: 03-9285 2257 Fax: 03-9285 4270
Southern region (Peninsular Malaysia)	Selia Selenggara (M) Sdn Bhd	Tel: 06-231 8140 Fax: 06-231 8246 Emel: adu2@selia.com.my
Sabah (Kota Kinabalu, Tenom, Sipitang, Beaufort, Keningau, Kota Belud, Kudat and Federal Territory of Labuan)	Lintasan Resources Sdn Bhd	Tel: 088-538168 Fax: 088-538163 Emel: webmaster@lintasan.com.my
Sabah (Sandakan, Telupid, Lahad Datu, Kunak, Beluran and Tawau)	Gammerlite Sdn Bhd	Tel: +60 88 714 439 Fax: +60 88 714 696 Email: info@gammerlite.com
Sarawak (Kuching, Samarahan, Sri Aman, Sarikei region)	PPES Works Sdn Bhd	Tel: 082-340 588 Fax: 082-340 695 Emel: works@cmsb.com.my
Sarawak (Sibu,Mukah, Bintulu region)	HCM Engineering Sdn Bhd	Tel: 084-339300 Fax: 084-344200
Sarawak (Miri, Limbang, Kapit region)	Endaya Construction Sdn Bhd	Tel: 082-230777 Fax: 082-234777

Road Maintenance

Maintenance Concessionaires - State Roads

Table D2: Maintenance Concessionaires for State Road

State	Company	Contact
Perak	Empayar Indera Sdn Bhd	Tel: 05-241 2870
Terengganu	Permint Granite-HCM Sdn Bhd	Tel: 09-667 1373
Selangor	KPS-HCM Sdn Bhd	Tel: 03-9282 2246
Kelantan	Senggara Timur Sdn Bhd	Tel: 09-741 2340 Fax: 09-741 2341 Email: online@selenggaratimur.com
Pahang	YP Maintenance Sdn Bhd	
Sabah	Globinaco Sdn Bhd	Tel: 088-266 600
Sarawak	CMS Roads Sdn Bhd	Tel: 082-233311 Fax: 082-230311 Email: hotlinejlnraya@works.cmsb.com.my
Melaka	Syarikat Pembinaan Al-Joffrie Sdn Bhd	Tel: 06-233 3190
Johor	Teto Engineering Sdn Bhd Amona Infra Care Sdn Bhd	

Road Maintenance

Bridges along Federal Roads

Presently, the Public Works Department maintains an inventory of 9,157 bridges along the Federal Roads in Peninsular Malaysia. About 69.9% of these bridges are culvert with span more than 0.5 m. The number of 'true' bridges is 2,464; about 27% of which are simple girder bridges. In terms of the construction material of the superstructure, PW record shows that about 90.3% of the structures are made of concrete. The two charts show the statistics of bridges on Federal roads by material types and bridges on Federal Roads by states. PWD manages the bridge stock by carrying out the mandatory annual bridge inspection and prioritising their maintenance program with the help of the Bridge Management System (BMS).

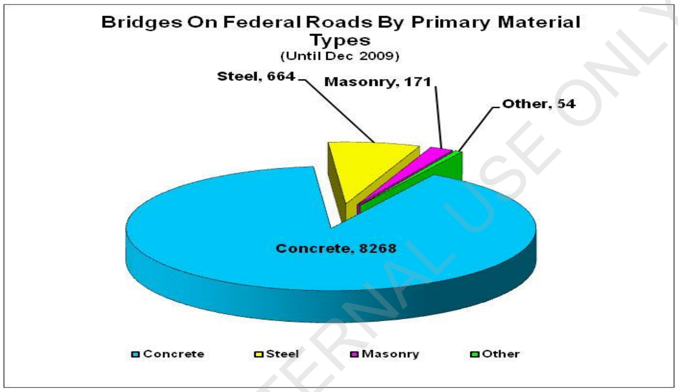


Table D1: Concessionaires And Their Respective Zone For Maintenance Work Are Based On The Following Regional Position

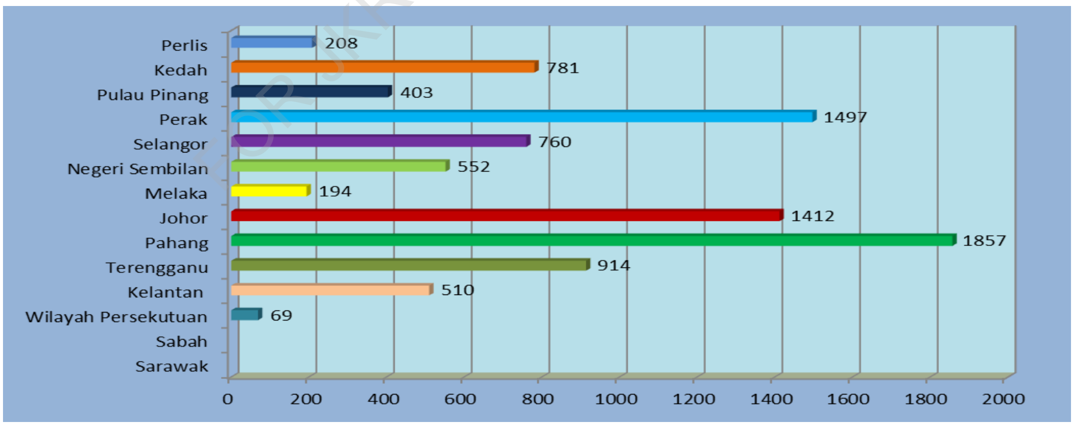


Figure D2: Inventoried Bridges along Federal Roads Breakdown of 9,157 bridges by states Source: Cawangan Senggara Fasiliti Jalan, JKR 2013

Road Maintenance

Weight Restriction Order

Structural integrity of bridges can be compromised by overloading of vehicle traversing on these bridges. Therefore, it is necessary to regulate the traffic and vehicle configuration in order for our roads and bridges to be operable till the end of its design life.

Hence, a National Axle Load Study for the principal Federal Roads was conducted and finalised in 1988. Following the study, the Weight Restriction Order 1989 covering Federal Roads Weight Restriction Order (WRO) which defines the routes for movement of vehicles with different categories of axle loading and configuration, was gazetted and came into force on the 1st January 1990.

This WRO specifies the limits of vehicle weights on Federal Roads by categorising them into **seven (7) load classes** with a schedule of the roads in each load class provided. This categorisation is necessary not merely due to difference in bridge design criteria but rather to the road geometric considerations. The maximum permissible Gross Vehicle Weights (GVW) specified for each load class depends on the number of axle configuration and vehicle dimensions.

Some of the bridges along the particular route are strengthened or replaced to allow for higher carrying capacity. However, the connecting state roads have a lower Weight Restriction Order. Heavy goods vehicles are required to unload their goods onto smaller vehicles before traveling along lower WRO State roads to their final destination.

However, the expansion of the heavy industry sectors have resulted in more industrial estates being set up further away from the hedges of major Federal roads. The new industrial estates are normally linked to major Federal roads by the state roads. In some cases, bridges along the State Roads became incapacitated due to the increase in gross loadings that were not accounted for during planning stage. The results of the State Axle Load Study Phase 1, (2002) on 1324 structures have shown that about 10% of the structures need to be strengthened or replaced in the long term. The study also recommended modification of the Weight Restriction Order (WRO) for several state roads.

Road Maintenance

Weight Restriction Order

The Weight Restriction Order, 1989 was revised in year 2003 due to the increased demand in the transportation industries and construction of higher standard of roads and highways. The Weight Restriction (for Federal Roads) (Amendments) Order 2003 was gazetted on 1st July 2003.

The major amendments to this Order are:

1. The revision of the wheel load and the axle load,
2. The maximum permissible gross vehicle weight (GVW, and GCW),
3. Road are classified under 5 load classes (List I, List II, List III List IV and List not under I to IV).

With this new WRO, Public Works Department (JKR) has raised the standard axle load for Class 1 Federal Roads from 10 tons to 12 tons and not State Roads. Class 1 Federal Roads includes most stretches of the toll highways and major Federal roads. This action was taken in view of fact that numerous bridge replacement and upgrading projects have been undertaken along those roads since 1989. The revised schedule now categorized five (5) load classes instead of 7.

PWD has undertaken the 2nd Phase of State Roads Axle Load Study, which involves the states of Penang, Perak, Kedah and Perlis. The study was completed in early 2009.

In the 9th Malaysia Plan, PWD will upgrade or replace 66 bridges at a total cost of RM239.1 million.

There is now a need for the states to modify the WRO on state roads in line with the setting up of new economic corridors. PWD is also reviewing the WRO on Sabah and Sarawak for the same purpose.

Table D3: Maximum Load (tonnes)

Axle ConConfiguration	Gazetted Load Classes				
	1	2	3	4	5
WEEL LOAD					
Single Wheel	3	3	3	2.5	
AXLE LOAD					
SingleAxle					
1. Two Wheel axle	6	6	6	5	6
2. Four wheel axle	12	10	8	6.5	9
Tandem Axle	16-19	14-16	13	8	14
Triaxle Load	19-21	16-18	14-16	-	15-17

Road Maintenance

Maximum Permissible Vehicle Weight

Table D4: Maximum Permissible Vehicle Weight

Type of Vehicle		Maximum Weight (Tonnes) Based On List Of Loading Class				
		I	II	III	IV	V
2 Axle-Rigid Vehicle		18	16	13	11	15
3 Axle-Rigid Vehicle		26	21	19	13	20
4 Axle-Rigid Vehicle		33	25	22	14	24
3 Axle-Articulated Vehicle		30	26	22	16	24
4 Axle-Articulated Vehicle		37	32	26	18	29
5 Axle-Articulated Vehicle		40	34	-	-	32
6 Axle-Articulated Vehicle		44	38	-	-	36
7 Axle-Articulated Tanker		53	-	-	-	-

Road Maintenance
Maximum Permissible Vehicle Weight

Information on the Pavement's Condition
Road and pavements is continuously subjected to traffic, progressively damaged by traffic loading. Its conditions therefore changes with time and thus reflects its usage.

An inventory of highway condition data is necessary for monitoring purpose. This database needs to be updated on a routinely regular basis in order to determine the condition of the pavement and whether its level of deterioration is such that remedial action is necessary. The data compiled will allow trends in the structural condition of a pavement to be established.

The four major types of routine assessment are :

1. Visual condition surveys
2. High speed road monitor - road scanner
3. Benkleman Beam / Falling Weight Deflectometer
4. SCRIM / Grip Tester

Visual Condition Surveys record defects that remain undetected by machine-based methods. As the method is slow and laborious, it is usually targeted on specific areas in particularly poor condition. The surveys provide factual information for deciding on the most appropriate structural treatments, and identify sections of highway suitable for remedial treatment. Planning for long-term treatment can thus be undertaken, with performance of the pavements being monitored and priorities for treatment being established on the basis of the database compiled.

High Speed Road Monitor (HRM) measures parameters such as riding quality, texture and rutting. It consists of a vehicle and 4.5 metre-long trailer fitted with four laser sensors along the nearside wheelpath. It allows the condition of the highway's surface to be assessed under conditions of normal traffic with speeds up to 95km/h.

Benkleman Deflection Beam is a widely accepted instrument for assessing the structural condition of flexible highway surfacing. It involves applying a moving load to the pavement's surface and monitoring its consequent vertical deflection. The deflection that occurs at the time and position of application of the load is termed the maximum deflection. The deflection that remains after the load is removed (permanent deflection) is termed the recovery deflection. It is the cumulative effect of the latter type of deflection that leads to cracking, rutting and ultimately failure of a pavement.

Figure D2: High Speed Road Monitor (HRM)

Figure D3: Benkelman Deflection Beam

Road Maintenance

Pavement Condition Assessment

Falling Weight Deflectometer is used to assess the structural condition of a highway pavement. It allows the deflected shape of the pavement surface to be measured. Estimates of layer stiffness (elastic modulus and Poisson's ratio) can be derived from information on this deflected shape together with the thickness and make-up of each of the individual strata.

SCRIM (Sideway Force Coefficient Routine Investigation Machine) constitutes a major form of routine assessment of a highway's condition. It measures the skidding resistance of the highway surface that is being gradually reduced by the polishing action of the vehicular traffic.

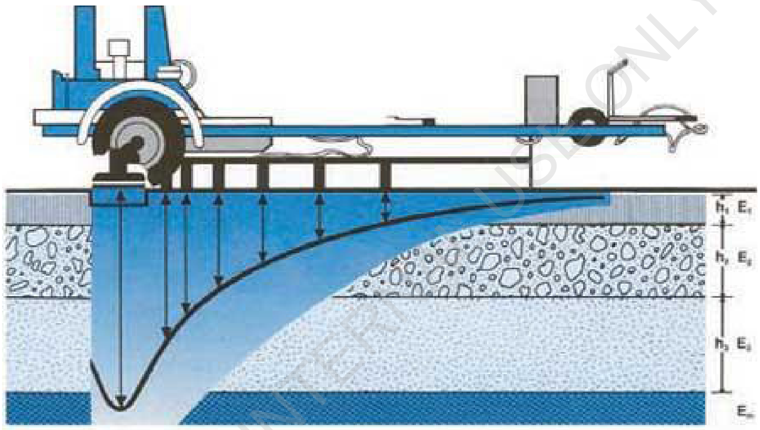


Figure D4: Falling Weight Deflectometer

Figure D5: Grip Tester

Figure D6: Sideway Force Coefficient Routine Investigation Machine (SCRIM)

Grip Tester can be pushed by hand or towed behind a vehicle that can travel at speeds of up to 130km/hr. A measuring wheel rotates at a slower rate than the main wheels of the apparatus and a film of water is sprayed in front of the tyre. A computer lodged within the apparatus monitors both the vertical load and the frictional drag acting on the measuring wheel. Operated at lower running costs than the SCRIM apparatus, its ability to be hand-pushed enables it to be used in pedestrian areas.

Road Maintenance

Pavement Maintenance

After a time, cracking, rutting and polishing of the road's surface will appear until it compromises the integrity of the pavement and the standard of service provided. Maintenance is required to prolong the highway's useful life and the inventory of highway condition data is used to determine the schedule for maintenance.

Select the most effective form of maintenance by considering the problems and other factors such as the optimum time the work should be undertaken. Some problems can only be solved with certain techniques. The list below describes some of the maintenance techniques available for asphalt surfaced pavement.

Crack repairs

When cracks are narrow (5 - 25 mm) and not deteriorated on the edge, crack repairs are a good alternative. Crack repairs generally fall into two categories of work: sealing and filling. Sealing prevents the intrusion of water and debris into a working crack. Filling reduces the infiltration of water into a non-working crack.

Patching

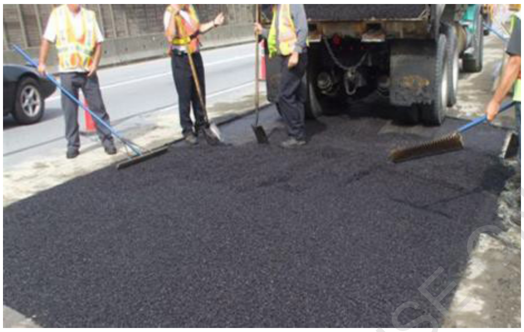
Patching is a year-round activity and an economical method to keep road surfaces drivable. Most patching is done to fill potholes. Ruts, slippage and other pavement defects may also be fixed best by patching. Patching does not fix base problems. Types of patches include: cold asphalt "throw and roll," hot asphalt "semi-permanent," and spray patching.

Road Maintenance

Pavement Maintenance

Area repairs

Unlike patching, area repairs is more extensive involving a cut out and replacement of a bad section of a road. Relatively expensive but since it fixes any base problems and is not wasteful, can be the best alternative for roads with small areas of distress.



Thin wearing courses

Sometimes called surface treatments or seals and are generally less than 25mm thick. Consisting wide variety of repairs commonly used to waterproof the pavement, restore skid resistance, and restore oxidized surfaces. Some surface treatments can fill minor ruts. Cracks and other defects will reflect through. Thin wearing courses do not alter surface undulation or add any structural strength.

Overlays

Generally greater than 25mm thick, an asphalt concrete overlay adds strength and can correct minor ride defects. Deficiencies addressed include surface ravelling, excessive patching, poor skid resistance and minor surface irregularity. Thin overlay on cracked pavement is risky unless the cause of cracking is removed as the crack may 'reflect' on the surface.

Road Maintenance

Pavement Maintenance

Recycling

Recycling is the reuse of the asphalt surface, but it does not usually reuse the base. This environmentally-friendly technique fixes cracks and restores the surface, but it does not fix any base quality or drainage problems.

Reclamation

Reclamation or stabilization improves the base, as opposed to recycling, which does not. This is done via the addition of aggregates or chemicals to improve the quality of the base. When completed properly, it provides an almost new road. Reclamation can be very cost-effective, but the choice of stabilizing agent is very critical.

Total reconstruction

This last resort is a very expensive technique, but it may be the only option for a badly deteriorated road. Total reconstruction can be cost-effective if done in conjunction with utility replacement.

Road Maintenance

Bridge Maintenance

Types of bridge inspection are as follows:

a) Inventory inspection
Is the first inspection carried out by the inspectors at the regionallevels on a particular bridge to collect inventory data. This inspection is done visually and systematically on every bridge in then etwork. Dimensioned measurements, sketches and
photographs are taken and recorded onto the inventory card of each bridge.

b) Routine condition inspection
Is a routine inspection carried out at the regional level for the purpose of rating the bridges based on their physical conditions and to ensure the safety of these bridges. This type of inspection is done visually following a checklist. This inspection can be done at least once a year, preferably during the period after the flood season.

c) Confirmatory inspection
It follows the routine condition inspection, to ensure that reporting done by the regional inspection teams are consistent with the established rating criteria. This inspection shall be carried out by inspection teams from the Headquarters on those bridges that are reported to be defective. The inspection will also enable the Headquarters to prepare the programme for bridge maintenance or further detailed inspection.

d) Detailed inspection
It shall be carried out by engineers from the Headquarters after the confirmatory inspection had identified the need for the bridge to be rehabilitated. The bridge engineers will inspect the defects on the bridge and this include taking and testing samples of defective materials and partly to assess the cause and extent of damage. Recommendations will then be made on the most feasible rehabilitation method Listed below are types of damage/defect that can be expected of bridges:

General guide in detecting bridge defects:

a) Main beam: Detecting corrosion, fracture/cracks, abnormal noise, deformation, spalling, delamination, abnormal vibration, paint deterioration etc.
b) Deck slab: Detecting corrosion, cracks, abnormal noise, deformation, spalling, delamination, abnormal vibration, water leaks, surface defeats, etc.
c) Abutments: Detecting corrosion, cracks, deformation, scouring, tilting, settlement, scouring, debris and vegetation etc.
d) Bearings: Detecting corrosion, ponding water, abnormal bulging, abnormal displacement of pad, etc.
e) Drainage: Detecting water leakage, no or inadequate pipe length, blocked, etc.
f) Parapet: Detecting corrosion, cracks, spalling, impact damage etc.
g) Railing: Detecting cracks, paint deterioration, deformation, etc.
h Pavement: Detecting potholes, rutting, settlement, cracking, rippling, loss of bond, etc.
i) Expansion joint: Detecting cracks, abnormal spacing, water leakage, abnormal noises, difference in level, rupture etc.
j) River bank: Detecting erosion, defects (illegal waste proposal, shack, pen), etc.

Road Maintenance

Bridge Rehabilitation Methods

Defects	General Rehabilitation Methods / Reasons	Injection	Patching	Gunitting	Surface Coating	Jacketing	Lining	Steel Plate Bonding	Additional Prestressing
Crack	-Effect of Excessive Load <1	O	O			O	O	O	
	- Design Deficiencies <2	O	O			O	O	O	O
	-Improper Construction <3	O	O	O	O	O	O	O	O
	- Environmental Effect <4		O	O	O				
	- Disaster <5	O	O	O	O	O	O		
	- Aggravation of Foundation <6	O				O	O	O	O
Spalling & Section Loss	- Effect of Excessive Load <1		O	O		O	O	O	
	- Design Deficiencies <2	O	O	O		O	O	O	
	- Improper Construction <3		O	O	O				
	- Environmental Effect <4		O		O	O	O		
	-Disaster <5		O	O		O	O		
Rebar or PC cables exposed, Corrosion of Rebar or PC Cables	- Design Deficiencies <2			O		O	O	O	O
	- Improper Construction <3		O	O	O	O	O		
	- Environmenatal Effect <4		O	O		O	O		
	- Disaster <5		O	O		O	O		
Deterioration	- Improper Construction <3	O		O		O	O		
	- Environmental Effect <4			O	O	O	O		
	- Disaster <5				O	O	O		

Notes:

0 Generally applicable

<1 Increase of dead and live loads

<2 Inadequate amount of rebars or PC force, inadequate concrete cover, wrong structural analysis or incorrect structural model

<3 Poor concrete quality, inadequate concrete cover, honey comb, poor cold joint, improper supporting or form work, inadequate P.C.force, inadequate grouting, improper compaction or vibration work

<4 Carbonation, chloride attack, acid attack, sulphate attack, alkali -aggregate reaction, shrinkage

<5 Fire, collision

<6 Local scouring, reduced bearing capacity, adjacent construction effect

Source: The Study on the Maintenance and Rehabilitation of Bridges in Malaysia, Bridge Inspection, Maintenance and Rehabilita tion Manual

Road Maintenance

Road Project Acceptance Criteria

Before a road project is handed over to the Road maintenance Division, it shall be inspected and assessed accordingly. It is required to comply the Road Project Acceptance Criteria (RPAC)

Based on Surat Arahan KPKR Bil. 3/2009, road project acceptance criteria can be categorized based on specification of contract used as below:

a) JKR/SPJ/1988
b) JKR/SPJ/2008-S4

RRAC for Contract based on specification JKR/SPJ/1988 as below:

Before Certificate of Practical Completion (CPC)

1. Pavement
- Longitudinal irregularity (shall comply with sub-section 4.4.3 JKR/SPJ/1988)
- Transverse irregularity (rut depth) ≤ 4 mm
- No crack
- No pothole
- No bleeding

2. Shoulder
- Flush and proper gradient from edge of pavement to RSD
- Pavement/shoulder difference ≤ 25 mm.
- Irregularities (depression more than 150 mm) ≤ 1m^2

3. Culvert

Major
- All culverts constructed as per drawings (no., size, type).
- Water flowing = 100%.
- Subsidence of adjacent pavement ≤ 10 mm.

Minor
- Debris in culvert ≤ 10 mm.
- Water ponding inside culvert ≤ 10 mm.
- Gap between joints ≤ 6 mm.

4. Drainage

Major
- All drains constructed as per drawings (length, size, type).
- Water flowing = 100%.

Minor
- Debris in drain ≤ 10 mm.
- Water ponding in drain ≤ 10 mm.
- Gap between joints ≤ 6 mm.

5. Slope
- No slope failure.

6. Bridge
- Condition Rating for each component/member = 1 or 2

7. Mechanical & Electrical
- Acceptance of testing & commissioning, witnessed by HOMT.

8. Roadside Furniture
- Constructed as per drawing and in accordance with Arahan Teknik (Jalan).

9. Road Safety Audit
- RSA Stage 4 Part 3 has been carried out and action on all comments has been taken.

Road Maintenance

Road Project Acceptance Criteria

RPAC Contract based on specification JKR/SPJ/1988 as below:

Before Certificate of Making Good Defects (CMGD)

1. Pavement
- Longitudinal irregularity (shall comply with sub-section 4.4.3 JKR/SPJ/1988)
- Transverse irregularity (rut depth) ≤ 4 mm
- No crack
- No pothole
- No bleeding

2. Shoulder
- Flush and proper gradient from edge of pavement to RSD
- Pavement/shoulder difference ≤ 50 mm
- Irregularities (depression more than 150 mm) ≤ 1m^2

3. Culvert

Major
- Water flowing = 100%
- Subsidence of adjacent pavement ≤ 10 mm

Minor
- Debris in culvert ≤ 10 mm
- Water ponding inside culvert ≤ 10 mm
- Gap between joints ≤ 6 mm

4. Drainage

Major
- Water flowing = 100%

Minor
- Debris in drain ≤ 10 mm
- Water ponding in drain ≤ 10 mm
- Gap between joints ≤ 6 mm

5. Slope
- No slope failure

6. Bridge
- Condition Rating for each component/member = 1 or 2
- Subsidence of adjacent pavement ≤ 20 mm

7. Mechanical & Electrical
- In working condition

8. Roadside Furniture
- No fading/blemishes

9. Road Safety Audit
- RSA Stage 5 has been carried out and action on all comments has been taken

Road Maintenance

Road Project Acceptance Criteria

RPAC for Contract based on specification JKR/SPJ/2008-S4 as below:

Before Certificate of Practical Completion (CPC)

1. Pavement
- The lane International Roughness Index (IRI) measured for the whole length and each 100 meter section shall be less than 2.0 m/km as per sub-section 4.5.3 JKR/SPJ/2008-S4)
- No crack
- No pothole
- No bleeding

2. Shoulder
- Flush and proper gradient from edge of pavement to RSD
- Pavement/shoulder difference ≤ 25 mm
- Irregularities (depression more than 150 mm) ≤ 1m^2

3. Culvert

Major
- All culverts constructed as per drawings (no., size, type)
- Water flowing = 100%
- Subsidence of adjacent pavement ≤ 10 mm

Minor
- Debris in culvert ≤ 10 mm
- Water ponding inside culvert ≤ 10 mm
- Gap between joints ≤ 6 mm

4. Drainage

Major
- All drains constructed as per drawings (length, size, type)
- Water flowing = 100%

Minor
- Debris in drain ≤ 10 mm
- Water ponding in drain ≤ 10 mm
- Gap between joints ≤ 6 mm

5. Slope
- No slope failure

6. Bridge
- Condition Rating for each component/member = 1 or 2

7. Mechanical & Electrical
- Acceptance of testing & commissioning, witnessed by HOMT

8. Roadside Furniture
- Constructed as per drawing and in accordance with Arahan Teknik

9. Road Safety Audit
- RSA Stage 4 Part 3 has been carried out and action on all comments has been taken

Road Maintenance

Road Project Acceptance Criteria

RPAC for Contract based on specification JKR/SPJ/2008-S4 as below:

Before Certificate of Making Good Defects (CMGD)

1. Pavement
- The lane International Roughness Index (IRI) measured for the whole length and each 100 meter section shall be less than 2.0 m/km as per sub-section 4.5.3 JKR/SPJ/2008-S4)
- No crack
- No pothole
- No bleeding

2. Shoulder
- Flush and proper gradient from edge of pavement to RSD
- Pavement/shoulder difference ≤ 50 mm
- Irregularities (depression more than 150 mm) ≤ 1m^2

3. Culvert

Major
- Water flowing = 100%
- Subsidence of adjacent pavement ≤ 10 mm

Minor
- Debris in culvert ≤ 10 mm
- Water ponding inside culvert ≤ 10 mm
- Gap between joints ≤ 6 mm

4. Drainage

Major
- Water flowing = 100%

Minor
- Debris in drain ≤ 10 mm
- Water ponding in drain ≤ 10 mm
- Gap between joints ≤ 6 mm

5. Slope
- No slope failure

6. Bridge
- Condition Rating for each component/member = 1 or 2
- Subsidence of adjacent pavement ≤ 20 mm

7. Mechanical & Electrical
- In working condition

8. Roadside Furniture
- No fading/blemishes

9. Road Safety Audit
- RSA Stage 5 has been carried out and action on all comments has been taken

Road Maintenance

Who to Call

Any problems or complains regarding any Federal roads or Toll Expressway (Aduan Jalan Persekutuan) can be conveyed through the following facilities:

Ministry of Works
Webpage : www.kkr.gov.my
e-maklum Email : pro@kkr.gov.my
Telephone : 03-8000 8000 (1MOCC)

Public Works Department
Webpage : www.jkr.gov.my
e-aduan Email : aduan@jkr.gov.my
Telephone : 1-300-888-557
SMS : JKR<aduan>32728
Facebook : http://www.facebook.com/pages/JKR.MALAYSIA/
Twitter : @jkr_malaysia

Malaysian Highway Authority
Webpage : www.llm.gov.my
e-aduan Email : aduan@llm.gov.my
Telephone : 03-87383000



ROAD SAFETY

Road Safety

Global Plan for the Decade of Action for Road Safety 2011-2020

A framework for the Decade of Action

The guiding principles underlying the Plan for the Decade of Action are those included in the "safe system" approach. This approach aims to develop a road transport system that is better able to accommodate human error and take into consideration the vulnerability of the human body. It starts from the acceptance of human error and thus the realization that traffic crashes cannot be completely avoided. The goal of a safe system is to ensure that accidents do not result in serious human injury. The approach considers that human limitations - what the human body can stand in terms of kinetic energy - is an important basis upon which to design the road transport system, and that other aspects of the road system, such as the development of the road environment and the vehicle, must be harmonized on the basis of these limitations. Road users, vehicles and the road network/environment are addressed in an integrated manner, through a wide range of interventions, with greater attention to speed management and vehicle and road design than in traditional approaches to road safety.

This approach means shifting a major share of the responsibility from road users to those who design the road transport system. System designers include primarily road managers, the automotive industry, police, politicians and legislative bodies. However, there are many other players who also have responsibility for road safety, such as health services, the judicial system, schools, and non-government organizations. The individual road users have the responsibility to abide by laws and regulations.

The Plan for the Decade also recognizes the importance of ownership at national and local levels, and of involving multiple sectors and agencies. Activities towards achieving the goal of the Decade should be implemented at the most appropriate level and the involvement of a variety of sectors (transport, health, police, justice, urban planning etc.) should be encouraged. Nongovernmental organizations, civil society, and the private sector should be included in the development and implementation of national and international activities towards meeting the Decade's goals.

In this respect, having road safety related legislation in place is essential. Such legislation should be harmonized among countries as much as possible. Therefore the major related United Nations international agreements and conventions should become the basis of global road safety legislation, as indicated in General Assembly resolutions and reports. Moreover, special attention should be given to the most vulnerable groups, those living in countries of conflict or where road safety is not embraced as a quality of life concept.

Road Safety

Global Plan for the Decade of Action for Road Safety 2011-2020

Goal and specific objectives

The overall goal of the Decade will be to stabilize 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 United Nations road safety related agreements and conventions, and use others as principles for promoting regional ones, as appropriate;
- developing and implementing sustainable road safety strategies and programmes;
- setting an ambitious yet feasible target for reduction of road fatalities by 2020 by building on the existing frameworks of regional casualty targets;
- strengthening the management infrastructure and capacity for 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 better use of existing resources, including through ensuring a road safety component within road infrastructure projects;
- building capacities at national, regional and international level to address road safety.

Activities

Activities over the Decade should take place at 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 5 pillars below.

Figure E1: National Activities

Road Safety

Road Safety Plan Malaysian 2006-2010 and its Strategies

For the period 2006-2010, the Ministry of Transport had proposed a 5 year action plan which was tabled and approved by the Cabinet on 15 march 2006. This 5-year plan outlines a number of strategies to address road safety issues covering education, enforcement, engineering and environmental issues.

Central to this 5-year plan is the achievement of key targets set to make Malaysia at par with other nations having good road safety records. The goals in the Road Safety Plan 2006-2010 are to achieve the following targets for the fatality indexes by 2010, an ambitious but not impossible targets when compared with the
2005 baseline figures.

Table E1: Comparison of fatality target index for 2010 and 2005

Fatality Index	2005	2010
Road deaths per 10,000 vehicles	4.2	2.0
Road deaths per 100,000 population	23.7	10
Road deaths per 1.0 billion vehicle kilometer travelled	19.6	10

Source: MIROS

The Ministry of Transport through Road Safety Department & Malaysian Institute of Road Safety Research (MIROS) has develop a new road safety plan for the year 2014-2020 to replace the previous Road safety plan. It is also a part of the Government's initiatives under the 'United Nations Decade of Action for Road Safety 2011-2020'

Based on an analysis of past trends, if:

- 'Business as usual' scenario
- No comprehensive road safety programme!
- No additional interventions or programmes!
- To address issues related to road safety in the country. This Plan is designed to achieve a set of outcomes through holistic approach and effective implementation of a comprehensive set of strategies.
- The main objective: To reduce the projected deaths due to road accidents in 2020 by 50%, e.g. from 10,716 fatalities to 5,358**.**

Table E2: Prediction of The Road Fatalities and Its Reduction

	2015	2020
Prediction of Road Fatalities	8,760	10,716
Reduction Fatalities	6,570	5,358

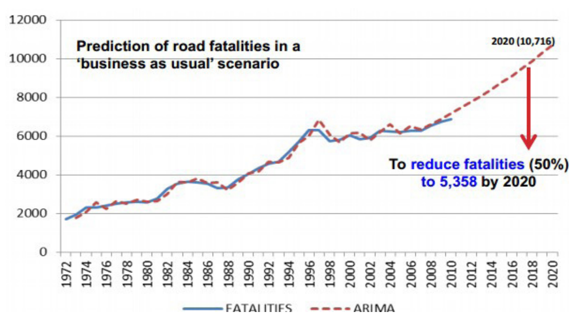


Figure E2: Fatality Prediction Source: MIROS

Road Safety

Road Safety Plan Malaysian 2014 - 2020 and its Strategies

The national Road Safety Plan 2014 - 2020 provides a coherent framework for the implementation of road safety initiatives in the country It is also a rolling plan and will be continuously adjusted to reach the goal of reducing deaths and injuries from road accidents. In conformity with the Global Decade of Action, activities shall be implemented according to the 5 Strategic Pillars as follow:

1. Strategic Pillar 1 - Road Safety Management
2. Strategic Pillar 2 - Safer Mobility and Roads
3. Strategic Pillar 3 - Safer Vehicles
4. Strategic Pillar 4 - Safer Road Users
5. Strategic Pillar 5 - Post-Crash Management

In Strategic Pillar 2 - Safer Mobility and Roads, there are 5 Final Outcomes (Reduction in Speed, Risk Reduction for Motorcyclists, Risk Reduction for Pedestrians, Reduction in Red Light Running and Risk Reduction for Car Occupants) and 1 Middle Outcomes (Reduction of risk associated with road engineering), implemented by PWD.

Road Safety Programmed

There are 7 Road Safety Program to be implemented to achieve the final outcome and middle outcome:

1. Evaluation of speed limits based on the type of road and vehicle
2. The method of speed control (traffic calming)
3. Management of traffic signals (synchronization and optimization of traffic signals)
4. Construction of motorcycle lanes and paved shoulders
5. Traffic barrier program
6. Evaluation standards and regulations program
7. Road Safety Audit Program

Source: MIROS

Road Safety

Our Rank in the World

In 2012, a record number of countries managed to reduce the number of road fatalities per 100,000 population to three or less, namely Iceland, United Kingdom, Norway, Denmark and Sweden. These countries may serve as role models for other countries, showing that further progress in road safety is always possible, even for the best performers.

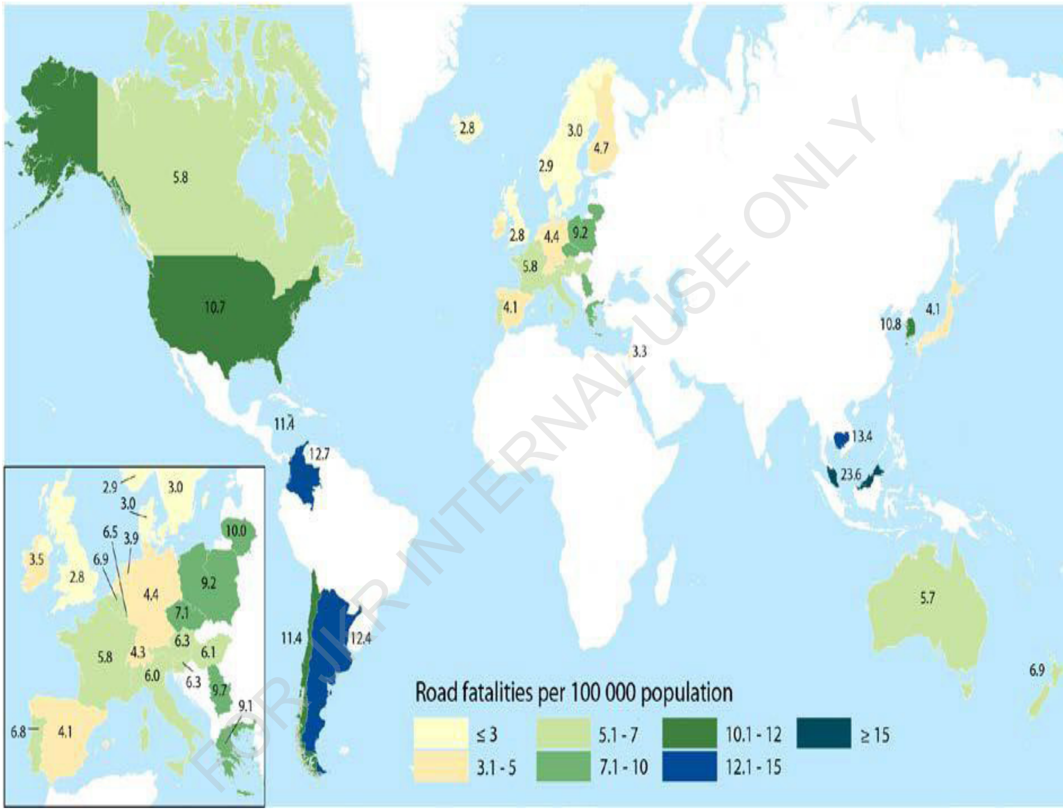


Figure E3: Road Fatalities per 100 000 Population in 2012 in IRTAD Member and Observer Countries Source: IRTAD

Road Safety

Our Rank in the World

Road fatalities per billion vehicle-kilometres in 2012

Data on risks expressed in terms of deaths per billion vehicle-kilometres are summarized in Figure E3. Analysis in terms of fatalities over distance travelled is a very useful indicator for assessing the risk of travelling on the road network. However, only a subset of IRTAD countries collects regular data on vehicle-kilometres. Based on this indicator, the situation has also improved substantially for all countries for which data are available. In 2012, the best-performing countries recorded less than five deaths per billion vehicle-kilometres; namely, Norway, Ireland, Great Britain, Sweden, Iceland, Finland, Denmark and the Netherlands.

Road fatalities per 10 000 registered vehicles in 2012

Figure E4 illustrates risk exposure expressed as the number of deaths per 10 000 registered vehicles. In the absence of data on vehicle kilometres for many IRTAD countries, the fatality rate per registered vehicle may be used as an approximation of exposurein order to describe risks and make comparisons between countries.

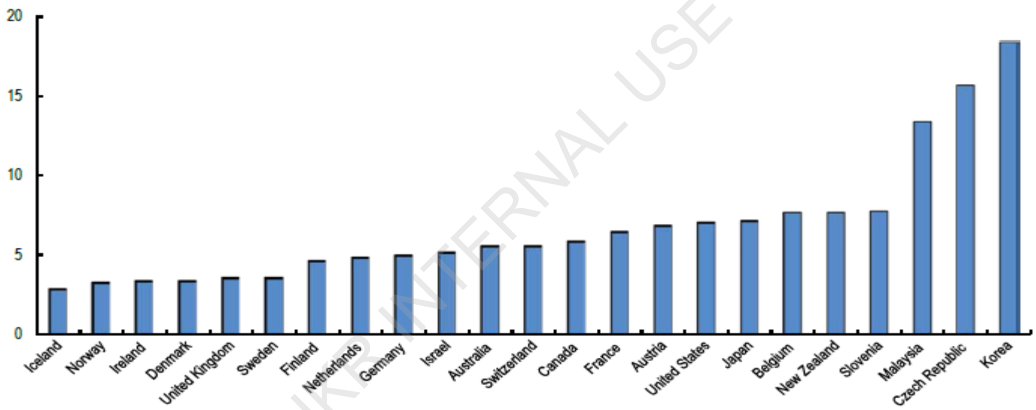


Figure E4: Road Fatalities per billion vehicle-kilometres

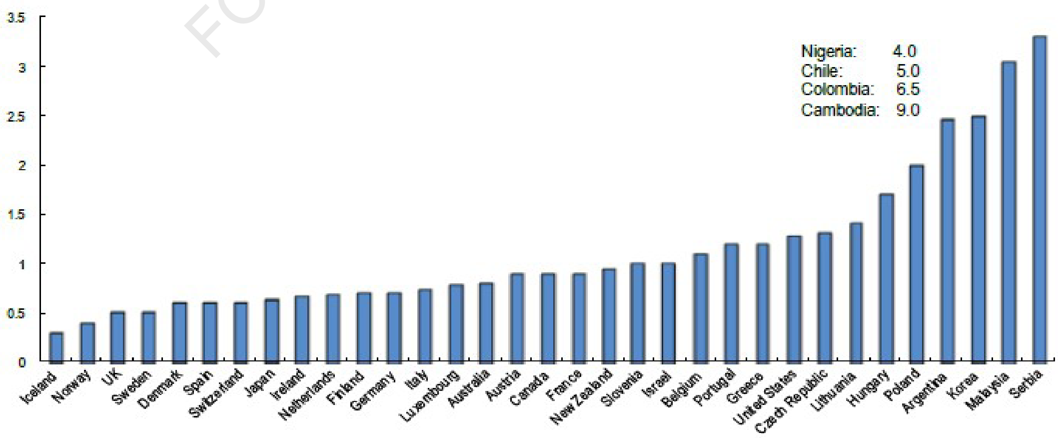


Figure E5: Road Fatalities Per 10 000 Registered Vehicles - Source: IRTAD

Road Safety

Alarming Facts about Global Road Traffic Accidents

1. Every year, there are 1.24 million road traffic deaths worldwide. Young adults aged between 15 and 44 years account for 59% of global road traffic deaths.
2. 92% of road traffic deaths occur in low- and middle-income countries. These countries have only 53% of the world's registered vehicles.
3. Vulnerable road users account for half of all road traffic deaths globally. Pedestrians, cyclists, and riders of motorized two-wheelers and their passengers are collectively known as "vulnerable road users". The proportion of road traffic deaths in vulnerable road users is greater in low-income countries than in high-income countries.
4. Controlling speed reduces road traffic injuries. Only 59 countries, covering 39% of the world's population (2.67 billion people), have implemented an urban speed limit of 50 km/h or less and allow local authorities to reduce these limits. A 5% cut in average speed can reduce the number of fatal crashes by as much as 30%.
5. Drinking alcohol and driving increases the risk of a crash. Above a blood-alcohol concentration (BAC) of 0.05 g/dl, the risk of road traffic crash increases dramatically. 89 countries, covering 66% of the world's population (4.55 billion people), have a comprehensive drink-driving law enforcing the WHO-recommended blood alcohol concentration limit of 0.05 g/dl or less.
6. Wearing a good-quality helmet can reduce the risk of death from a road crash by 40%. Wearing a good-quality helmet can also reduce the risk of severe injury by over 70%. 90 countries, representing 77% of the world's population, have a comprehensive helmet law covering all riders, all roads and all engine types, and apply a helmet standard.
7. Wearing a seat-belt reduces the risk of death among front- seat passengers by 40-65%. Wearing a seat-belt can also reduce deaths among rear-seat car occupants by 25-75%. 111 countries, representing 69% of the world's population, have comprehensive seat-belt laws covering all occupants in a car.
8. Infant seats, child seats and booster seats can reduce child deaths by 54-80% in the event of a crash. More than half of all countries have implemented a law on child-restraint use in cars.
9. Prompt, good-quality pre-hospital care can save the lives of many people injured in road traffic crashes. 111 countries have a universal national access emergency number, but only 59 countries have ambulance services available to transport over 75% of injured patients to hospital.
10. Since 2007, 88 countries have reduced the number of road traffic deaths. This suggests that progress can be made if there is sufficient political commitment. However, in 87 countries the number of road traffic deaths has increased, while at the global level the number of deaths has remained stable. The pace of legislative change and enforcement need to be hastened and more attention paid to vulnerable road users to reduce the number of road traffic deaths.

Source: WHO

Road Safety

Malaysian Fatality Prediction

Together with the Road Safety Plan is a set of broad and comprehensive framework on road safety which laid down 9 fundamental strategies. The objectives for these strategies are to achieve better road safety education, safer engineered road and vehicle, and effective enforcement. The 9 important strategies are:

1. Maintain and continuously improve the education on road safety,
2. Effective enforcement through utilization of new technologies,
3. Enhancing engineering initiatives pertaining to road safety issues,
4. Encourage and increase community participation,
5. Encouraging modal shift & use of public transportation especially for the vulnerable road users,
6. Focus on other critical sectors to enhance road safety such as better emergency assistance to road victims and trauma centres,
7. Focus on enhancing safety of high risk road users such as conspicuity programs for motorcyclists and media campaigns,
8. Re-examination and enhancing existing road safety regulations and
9. Promote sharing of funds and resources between public and private sector.

Source: MIROS

Road Safety

Causes of Death in Malaysia

Table E2 compared the position of road injury with other principle causes of death. Fatalities caused by road crashes have been estimated to account for 4.7% of the total death in the country.

Table E3: Number and Causes of Death in Malaysia

Top 10 Causes of Death	No. of Deaths (000s) 2012	Change in Rank 2000-2012
Ischaemic heart desease (20.1%)	29.4	No change
Stroke (10.6%)	15.5	No change
Lower respiratory infections (8%)	11.8	No change
Road injury (4.7%)	6.8	No change
Chronic obstructive pulmonary disease (4.6%)	6.8	No change
HIV/AIDS (3.3%)	4.8	No change
Diabetes mellitus (3.3%)	4.8	Increased
Trachea, bronchus, lung cancers (2.8%)	4.1	Decreased
Kidney diseases (1.9%)	2.8	No change
Breast cancer (1.7%)	2.5	Increased

Source: WHO

Road Safety

Road Accident Contributing Factors

Road traffic accident is defined as a rare, random, multifactor event always preceded by a situation in which one or more road users have failed to cope with their environment', resulting in a collision on the public highway which should be recorded by the police.

Traffic accidents rarely have a single cause, but are the result of 'a chain of events' and the interaction of (often) many factors which are generally categorised as **human, vehicle and road environmen**t. Studies have shown that the percentage contribution of each of these factors in a set of annual accident records may varies slightly between countries.

Presented herewith the chart is obtained from the PIARC Road Safety Manual.

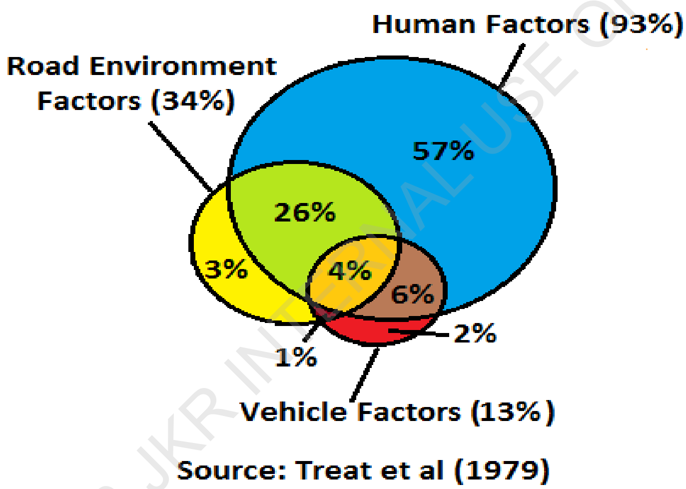


Figure E6: Accident Contributing Factors

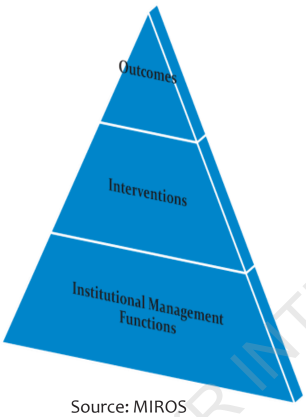
Road Safety

Safe System Approach

The Safe System Approach ideology is that 'an accident may happen, but it should not result in death or injury'. Its rationale is to ensure that road users are never subject to high impact energy level that can cause fatal or serious injury.

Safe System Approach underlines the need to approach road safety as a system, meaning that no one is at fault, but all of us - the authorities, government, vehicle manufacturers, operators, vehicle handlers and public, and the society at large are equally responsible.

A safe system approach is the key to achieving long term ambitious targets and offers new opportunities to reduce death and injury. This requires improvements across all facets of transport, hence, an integrated road safety system encompassing all aspects involving driver behaviour, speeds, vehicles, and roads.



Source: MIROS

Social Costs
Final Outcomes
Intermediate Outcomes
Outputs

User, Vehicle and Road/Environment
Pre-, during and post-crash

Results Focus
Coordination
Legislation
Funding and Resource Allocation
Monitoring and Evaluation
Research and Development
Knowledge Transfer

Table E4: Safe System Approach based on Haddon Matrix Framework

Pre-Crash	During Crash	Post-Crash	
Road User	• Road Safety Education • Driver Training Program and Grading of Driving Institutes • Automated Enforcement System • Publicity Campaigns • Community Based Programs: (VEM, Helmets, RSE, Rear Seat Belts) • Road User Assessment Program (RUAP)	Compliance and Correct Use of Active Safety Featues	Skills of Paramedics and First Respondents
Vehicle	• Type Approval/Construction & Use (C&U) • Vehicle Standards & Ratings • Vehicle Inspection • Rear Seatbelts • Under Run	Passive Safety System Crash Compatibility Tools	Ease of Evacuation
Environment	Road Safety Audit Blackspot Treatment Motorcycle Lanes iRAP	Clear Zones Barrier Systems Crash Cushions	Easy Access by First Respondent Teams Trauma Center

Road Safety
Crash Risk and Crash Severity

Crash Risk

You are more likely to collide with another car, hit a pedestrian or run off the road if you exceed the speed limit or drive at a speed which is not appropriate for the conditions. The probability of involving in an injury crash increases as the speed increase.

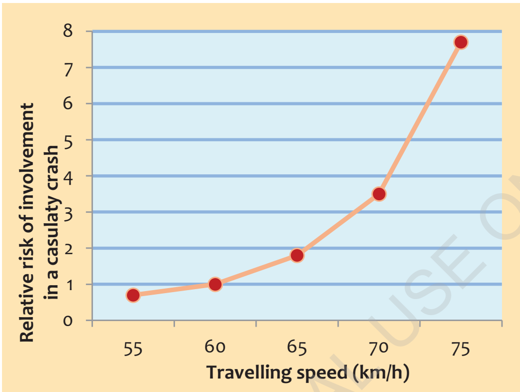


Figure E7: Crash Risk by Travel Speed in a 60 km/h Zone

The risk of injury crash doubles with a 5 km/h increase in travel speed - at just 65 km/h in a 60 km/h zone an injury crash is twice as likely to occur.

Crash Severity

Pedestrians are vulnerable to speed. Small differences in travelling speed can mean the difference between life and death. The survival rate of a pedestrian involved in a crash with a vehicle is dependent on the speed at the time of collision.

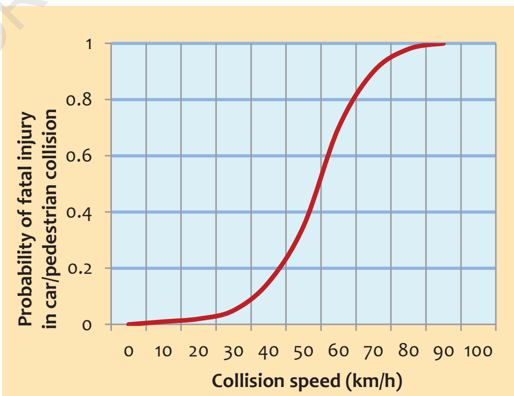


Figure E8: Car/Pedestrian Crash Severity by Collision Speed

At an impact of 60 km/h the pedestrian has little chance of surviving a crash - at an impact speed of 40 km/h the chance of survival for pedestrian is about 80 per cent.

Source: Vic Roads

Road Safety

Registered Vehicles and their Involvement to the Road Traffic Accident

Table E5: Registered Vehicles and their Involvement to the Road Traffic Accident

Year	Registered Vehicles	Vehicles Involve In Road Accident	Total Of Road Accident
2004	13,764,837	596,533	326,815
2005	14,733,585	581,136	328,264
2006	15,790,732	635,024	341,252
2007	16,813,943	666,027	363,319
2008	17,733,084	671,078	373,071
2009	18,933,237	705,623	397,330
2010	20,006,953	760,433	414,421
2011	21,311,630	817,151	449,040
2012	22,590,123	921,232	462,423
2013	23,434,640	901,823	477,204
2014	25,101,192	886,343	476,196

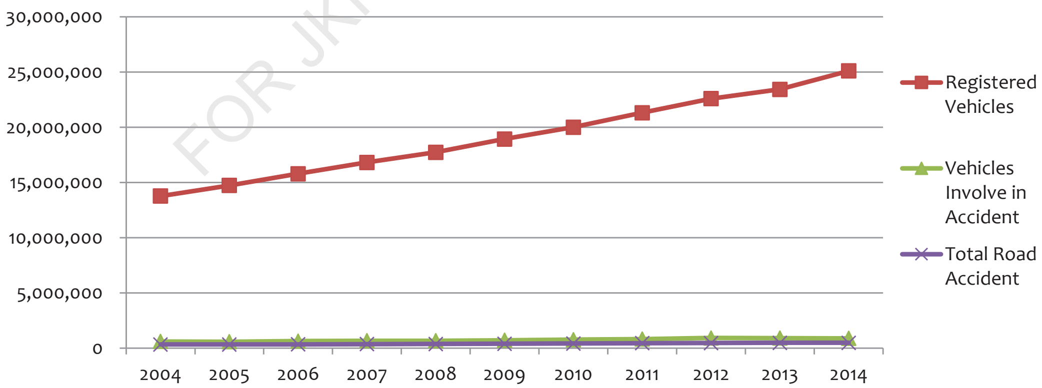


Figure E9: Registered Vehicles and involvement to the road traffic accident

Source: PDRM

Road Safety

Types of Road Accident

Table E6: Types of Road Accident

Year	Fatal	Serious	Minor	Damage Only	Total
2004	5,678	7,444	33,147	280,546	326,815
2005	5,623	7,600	25,905	289,136	328,264
2006	5,719	7,373	15,596	312,564	341,252
2007	5,672	7,384	13,979	336,284	363,319
2008	5,974	7,019	12,893	347,185	373,071
2009	6,218	6,978	12,072	372,062	397,330
2010	6,260	6,002	10,408	391,751	414,421
2011	6,349	4,875	9,438	428,378	449,040
2012	6,381	4,694	9,398	441,950	462,423
2013	6,308	3,567	6,523	460,806	477,204
2014	6,187	3,477	7,099	459,433	476,196

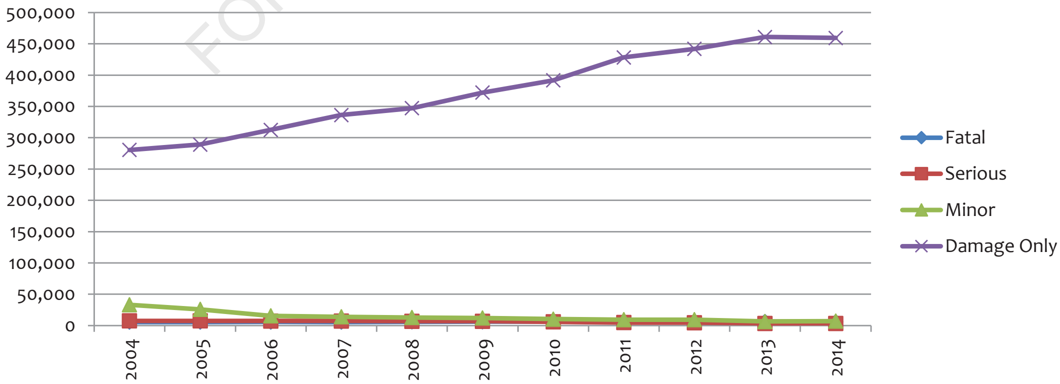


Figure E10: Types of Road Accident Source: PDRM

Road Safety

Types of Casualty

Table E7: Types of Casualty

Year	Fatal	Serious	Minor	Total
2004	6,228	9,218	38,645	54,091
2005	6,200	9,395	31,417	47,012
2006	6,287	9,253	19,885	35,425
2007	6,282	9,273	18,444	33,999
2008	6,527	8,868	16,879	32,274
2009	6,745	8,849	15,823	31,417
2010	6,872	7,781	13,616	28,269
2011	6,877	6,328	12,365	25,570
2012	6,917	5,868	11,654	24,439
2013	6,915	4,597	8,388	19,900
2014	6,674	4,432	8,598	19,704

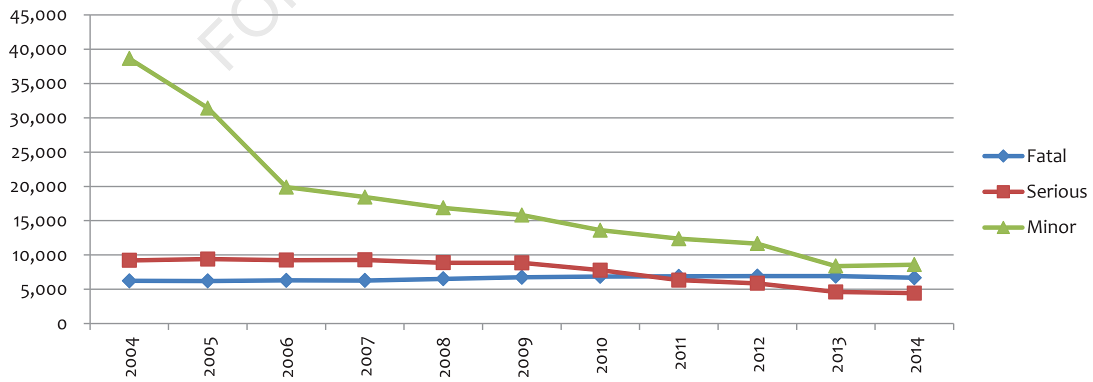


Figure E11: types of Casualty Source: PDRM

Road Safety

Road Accident by States

Table E8: Road Accident by States

Year	Perlis	Kedah	Pulau Pinang	Perak	Selangor	Kuala Lumpur	Negeri Sembilan	Melaka	Johor	Pahang	Kelantan	Tr'ganu	Sarawak	Sabah	Total
2004	1,073	14,196	31,008	27,542	87,891	44,240	14,505	11,020	41,854	13,349	7,000	7,254	13,865	12,018	326,815
2005	1,037	14,484	30,934	27,225	87,705	45,000	14,461	10,321	42,606	13,318	7,078	7,126	14,209	12,760	328,264
2006	1,160	15,505	32,573	27,432	92,632	46,254	15,197	10,707	43,757	13,242	7,098	7,337	14,808	13,550	341,252
2007	1,364	16,172	33,881	29,203	99,157	49,454	16,079	11,720	46,584	13,982	8,155	8,116	15,196	14,256	363,319
2008	1,417	16,520	34,049	30,539	100,380	48,671	17,362	12,105	48,667	15,629	8,814	8,842	15,488	14,588	373,071
2009	1,633	17,701	33,719	32,327	107,429	51,942	18,369	13,275	51,747	17,068	10,118	9,549	16,655	15,798	397,330
2010	1,548	17,966	34,306	32,072	115,565	53,493	19,407	14,110	55,381	17,315	10,106	9,707	17,253	16,192	414,421
2011	1,791	19,699	37,158	33,506	128,876	58,795	21,157	14,720	59,501	19,001	10,684	9,603	17,964	16,585	449,040
2012	1,881	19,935	37,851	34,714	129,106	61,872	22,146	15,195	62,316	20,554	10,861	9,968	18,578	17,446	462,423
2013	1,895	20,228	39,408	39,361	135,024	64,527	23,066	16,083	64,600	20,130	9,748	10,996	17,438	18,700	481,204
2014	1,888	20,159	38,747	35,131	137,809	63,535	23,748	16,375	64,473	19,071	10,326	9,383	17,858	17,693	476,196

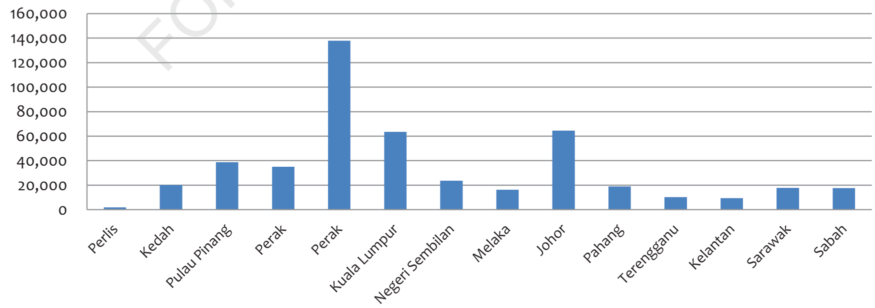


Figure E12: Road Accident by States (2014)

Source: PDRM

Road Safety

Road Accident and Casualty by Road Category

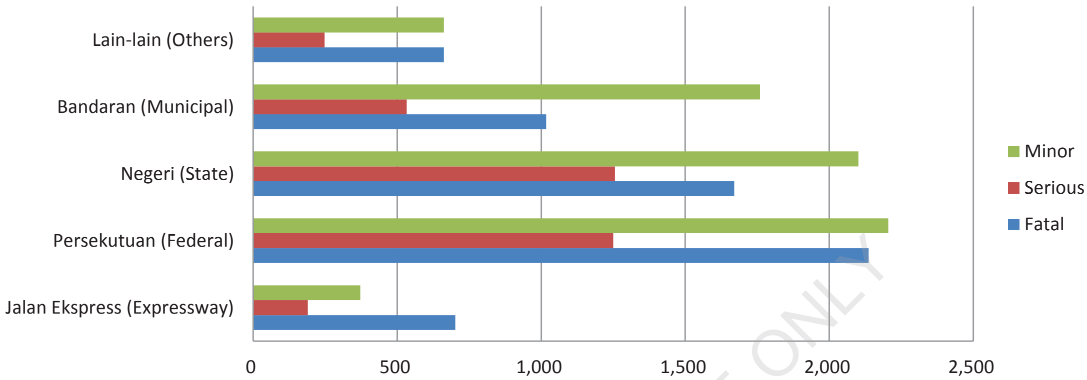


Figure E13: Road Accident by Road Category (2014)

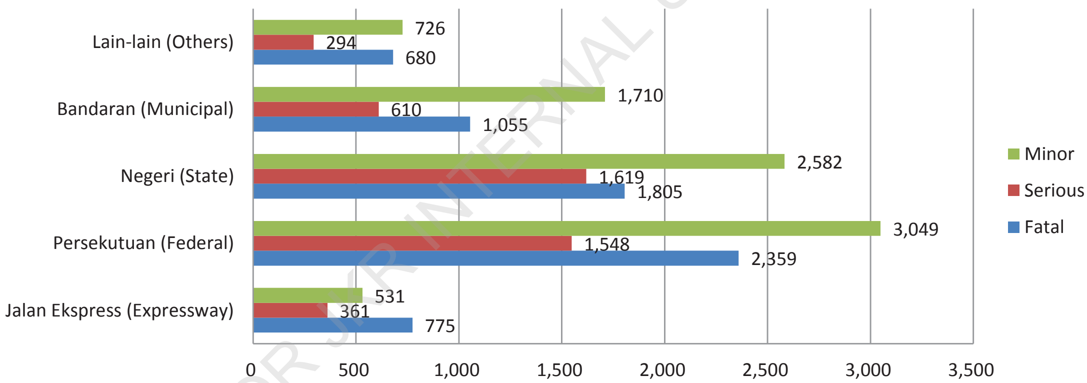


Figure E14: Casualty by Road Category (2014) Source: PDRM

Road Safety

Vehicles Involved in Road Accident

Table E9: Number and Types of Vehicle Involved in Road Accident

Year	Motorcar	Motorcycle	Lorry	Bus	Taxi	Van	4wd	Bicycle	Others	Total
2005	376,061	97,072	42,062	8,594	7,043	19,085	19,106	2,751	9,362	581,136
2006	411,444	104,107	44,767	9,700	7,751	20,428	20,885	2,834	12,266	634,182
2007	426,941	111,765	47,696	10,285	8,809	21,109	21,823	2,690	14,909	666,027
2008	435,665	111,819	48,250	9,356	8,769	20,392	22,793	2,463	11,571	671,078
2009	472,307	113,962	46,724	9,380	8,669	19,220	23,581	2,486	9,294	705,623
2010	511,861	120,156	50,438	9,580	9,899	18,788	25,777	2,178	11,756	760,433
2011	546,702	129,017	53,078	9,986	11,197	17,916	30,828	2,033	16,394	817,151
2012	655,813	130,080	53,774	10,617	11,680	16,604	35,867	2,000	4,797	921,232
2013	632,602	121,700	39,276	10,123	11,651	17,148	52,512	1,370	15,441	901,823
2014	617,578	125,712	37,481	9,193	10,856	15,041	41,464	1,275	27,743	886,343

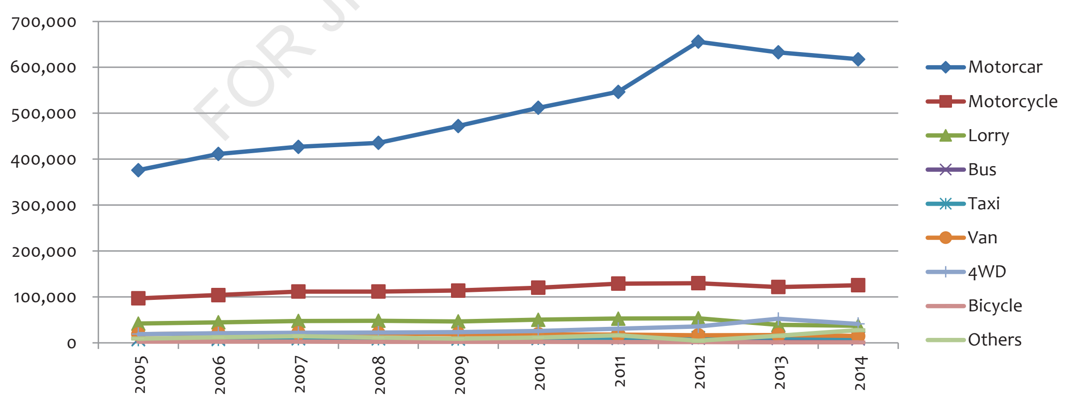


Figure E15: Number & types of vehicle involved in Road Accident Source: PDRM

Road Safety

Speed Limit

Speed limits are implemented by the road authority to inform motorists of the appropriate driving speeds and these limits are enforced by police or road transport authorities. This is done with an objective to improve road traffic safety and reduce the number of road traffic casualties resulting from traffic collisions. With proper enforcement, speed limit can be an effective traffic safety tool to improve the safety level of an area.

Speed limit is a regulatory traffic control means enacted under Section 69 of the Road Transport Act 1987 (Act 333) which is necessary to control speed of vehicles for safety reasons. Malaysia has imposed National Speed Limits for its road networks (90 km/h - non-expressways; 110 km/h - Toll expressways). However, much lower speed limits are sometimes required at various locations where safety measures are necessary. These sections of road assigned with lower speed limits than the national speed limit are commonly known as speed limit zones.

All speed control regulations, including those on speed limits provide the legal basis for adjudication and sanctions for violations of the law. In most cases mandatory speed limits are imposed at specific sections of the road but road authorities may also post advisory speed signs, which do not have the force of law. These signs are specially used to warn motorists of suggested safe speeds for specific conditions at a particular location (e.g., a turn or an intersection approach).

Road users are more likely to comply with a speed limit if it is consistent with limits on other roads in the network with similar characteristics, and if limits, in general, reflect the factors that most influence speed choice. The extent of roadside development and the function of a road are the primary determinants of the appropriate speed limit. Consistency is an important aspect in the speed limit selection procedure and should concur with the road users' perceptions of a reasonable speed limit that will influence their willingness to comply.

To eliminate any rule-of-thumb or arbitrary approach to the determination of local speed limits, a standard procedure established on the basis of engineering studies is required. Nonetheless, imposition of local speed limits shall only be done if it is deemed necessary for safety reason.

Basic Speed Law - no person shall operate a motor vehicle at a speed greater than is reasonable and proper for the prevailing conditions.
85th percentile speed - The speed at or below which 85 percent of the sample of free flowing vehicles is traveling. The 85th percentile of the distribution of observed speeds has been the most frequently used measures of the operating speed.
Design speed - the speed established as part of the geometric design process for a specific segment of roadway.
Operating speed - the speeds at which vehicles are observed operating during free flow conditions. Free flow speeds are those observed from vehicles whose operations are unimpeded by traffic control devices (e.g., traffic signals) or by other vehicles in the traffic stream.
Advisory speed - Advisory speeds are recommended safe speeds usually installed for curves, intersections, or other locations such as school zones where it is necessary to restrict operating speeds to less than the maximum legal speed or posted speed limit.

Road Safety

6-Step Procedure For Setting Of Speed Limit

6-Step Procedure

The approach in the application of the methodology is outlined in six (6) steps below:

STEP 1 : Establish Speed from Road Curvature
STEP 2 : Calculate Free Flow Speed (FFS)
STEP 3 : Establish Speed from Pedestrian Traffic, P STEP 4: Establish Speed from Average Weighted Point of Accident Occurrence, A
STEP 5 : Establish Speed from Legal On-Street Parking
STEP 6 : Select the Speed Limit

Source: Refer NTJ, guideline for the practical application of the selection of speed limit

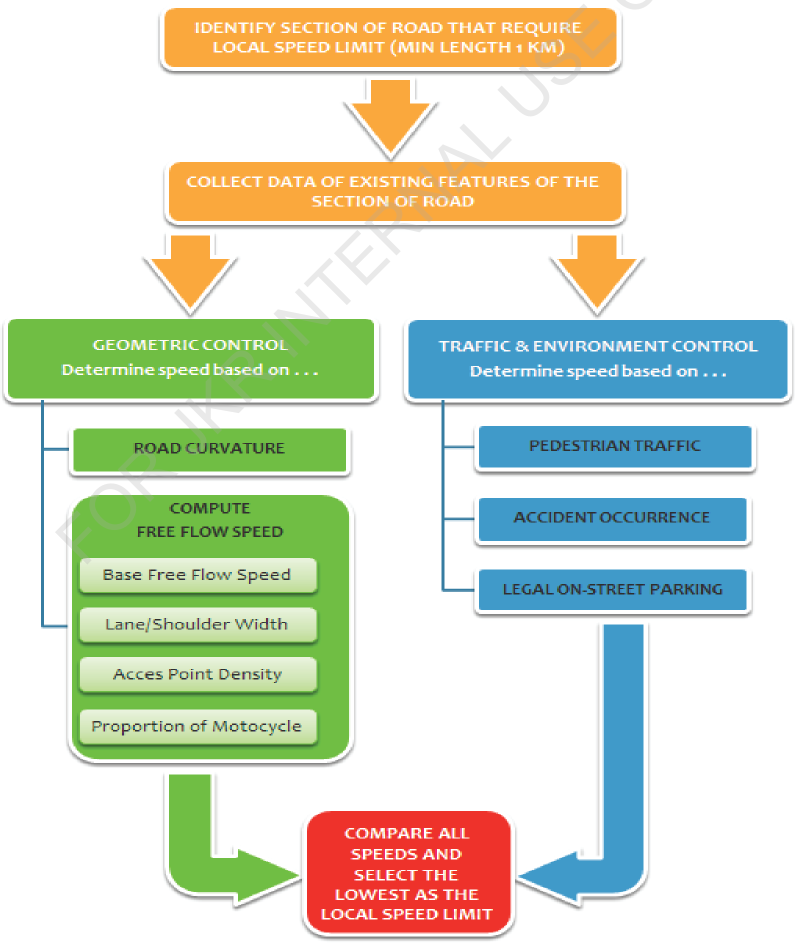


Figure E16: Flow Chart showing the 6-step procedure

Road Safety

Speed Limit - Application Rules

The procedure above does come with a set of rules that must be observed and they are summarised below:

1. This guideline is not applicable for a new road. If necessary, speed limit for new road shall be set based on the design speed of the road under the prevailing design conditions.
2. This guideline shall not be used in determining variable speed limits, speed limits at work zones or school zones.
3. For urban areas, zones with varying local speed limits shall only impose one local speed limit whichever the lowest.
4. For rural areas, zones with varying local speed limits shall be imposed if separated by a distance of more than 2 km where only the national speed limit applies.
5. If a school fronting the road exists within the speed limit zone, a 30 km/h Advisory Speed Limit sign shall be installed (refer to ATJ 2B/85 (Pindaan 2014): Manual On Traffic Control Devices: Traffic Sign Application).
6. Places of public interest or worship such as hospital, mosque, etc. are allowed to be imposed speed limits of between 30 - 50 km/h which shall be decided by the local authority.

Speed limit - the maximum lawful vehicle speed for a specific location. There are two types of speed limits, posted speed and statutory speed, definitions of each are provided.
Posted speed - one of two speed limit types (statutory speed is the other type); it is the maximum lawful vehicle speed for a particular location as displayed on a regulatory sign. Posted speeds are displayed on regulatory signs in speed values that are multiples of 5 km/h.

7. The speed limit for a particular length of road must reflect the road safety risk to the road users while maintaining mobility and amenity.
8. The lowest speed based on the list of criteria shall be the selected speed limit.
9. The Speed Limit sign shall display the approved speed in multiples of 10 km/h (to the nearest 10^{th} km/h on the lower side).
10. Speed zone changes should be kept to a minimum, balancing the need for a new speed zone with the possible confusion caused by frequent changes. If there are complaints received after the speed limit is imposed, a spot speed study shall be conducted. If found safe, adjustment (+/-) to the speed limit would then be done based on the 85^{th} percentile speed as determined.
11. Setting speed limits lower than the 85^{th} percentile speed may not encourage compliance with the posted speed limit. In such situations, engineering techniques or traffic calming measures should be used to lower vehicle speeds.

Statutory speed - one of two speed limit types (posted speed is another type). Numerical speed limits established by law that apply to various classes or categories of roads in the absence of posted speed limits.
Speed zone - a speed limit established on the basis of an engineering study for a particular section of road, for which the statutory speed limit is not appropriate.

Road Safety

Traffic Management During Construction

During construction of new roads or upgrading of existing roads, the movement of vehicular traffic and construction machineries within the construction area must be smooth and safe for all. In order to achieve this, systematic management and adequate traffic control devices need to be provided. Traffic management during construction is another aspect of road safety that is increasingly becoming important as the number of accident at construction areas increases.

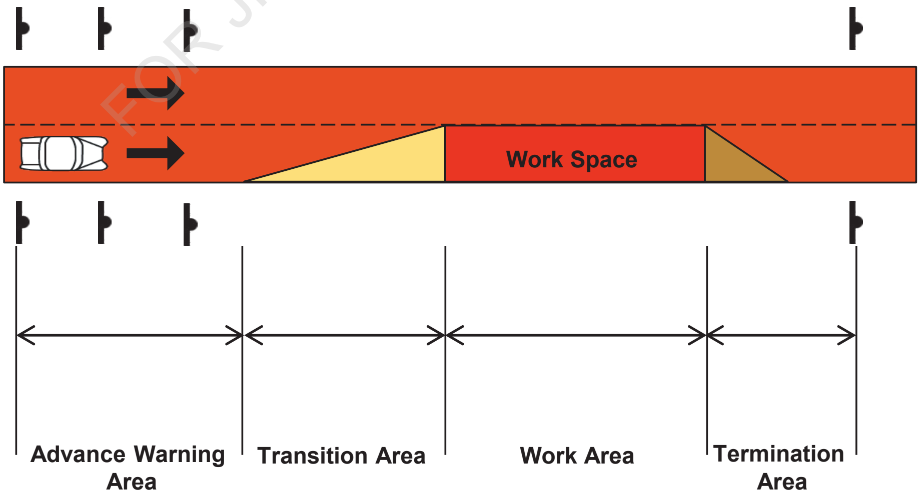


Figure E17: Arrangement at construction work zones

The traffic management scheme is generally being divided into several areas as shown above.

Table E10: Distance of the areas and spacing of Traffic Control Devices

Area		Distance	Spacing of Devices
Advance Warning Area	Expressways Rural Roadways Urban Roadways	1 - 2 km 350 m (min) 250 m (min)	Min. 50 m apart Min. 50 m apart Min. 15 m apart
Transition Area	Lane Closure Taper 2-way Traffic Taper Shoulder Closure Taper Downstream Taper	(See the following table) 15 - 30 m Half the values in the following table 15 - 30 m	(See the following table) 3 - 6 m apart (See the following table) 3 - 6 m apart
Buffer Space		Arbitrary	Double or four times the values in the following table
Work Area		Arbitrary	
Termination Area		15 - 30 m	3 - 6 m apart

Table E11: Taper Length for Lane Closure

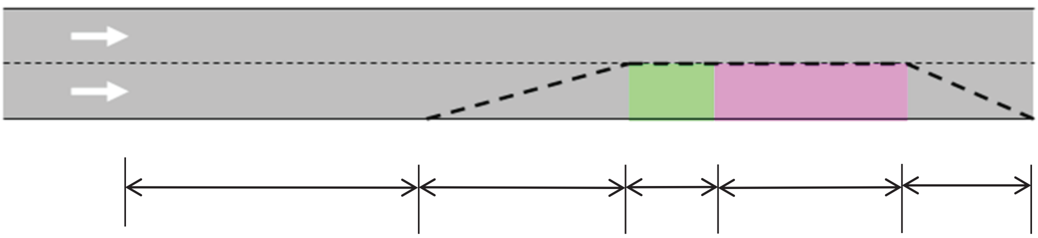
Speed Limit km/hr	Lane Width (m) Taper Length			Number of Channelizing Devices for Taper	Spacing of Along Devices Taper (m)
	3	3.5	3.75		
30	17	20	22	5	6
40	30	35	40	6	7
50	50	55	60	7	9
55	60	70	75	8	10
65	80	95	100	9	12
70	130	155	165	13	13
80	150	175	190	13	15
90	170	195	210	13	16

Table E12: Taper Length for Work Zone Control

Posted Speed	Formula
70 km/h or under	$L = \frac{WS^2}{155}$
70 km/h or over	$L = \frac{WS}{1.6}$
Where L = taper length W = width of lane or offset S = posted speed, or off-peak 85 percentile speed	

Road Safety

Choices for Traffic Control Devices



	Zone A Advance Warning	Zone B Transition	Zone C Buffer / Zone D Work Area	Zone E Terminate
TEMPORARY DIVERSION	Mandatory Advance Sign. Other signs are advantageous to have.	- Arrow Signs - Cones	- Arrow Signs - Cones	
SHORT TERM	Advance Warning Sign - apply the full set.	- Arrow Signs - Plastic NJBs	- Work Area, Speed Signs - Plastic NJBs - Delineators, Strings	
LONG TERM	Advance Warning Sign - apply the full set.	- Arrow Signs - Plastic NJB - Add TCDs	- Work Area, Speed Signs - Concrete, Plastic NJBs - Delineators, Strings	

Figure E18: Traffic control devices at work zones

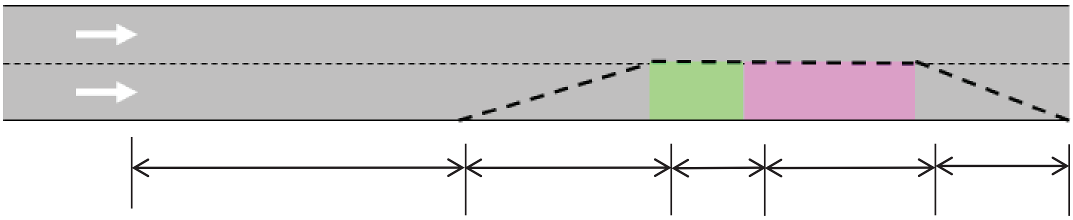
The figure above shows the choices of traffic control devices that shall be installed at various zones according to the duration of the work involved. The duration is categorised as temporary diversion, short term and long term.

Note:

TCDs - Traffic Control Devices
NJBs - New Jersey Barriers

Road Safety

General Sign Arrangement During Construction



Zone A Advance Warning		Zone B Transition	Zone C Buffer	Zone D Work Area	Zone E Terminate
	Use	Use	Use	Use	Use
1st Sign 2nd Sign 3rd Sign 4th Sign 5th Sign	- Identification Sign - Info Sign - Speed Sign - Info Sign - Speed Sign	Arrow Signs	Arrow Signs	Work Area Signs and Speed Signs	Warning Signs

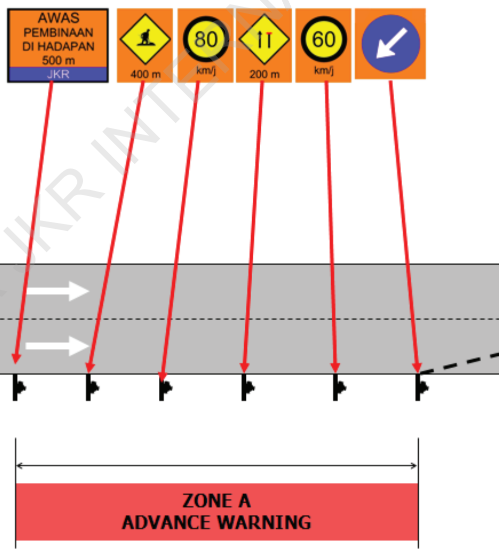


Figure E19: Traffic signs at work zones

Advance Warning Sign Arrangement During Construction

Arrow sign at the start of the Transition Area is to placed on high post.

Road Safety

Blackspot Definition

A road accident blackspot is basically a location where there is a high number of accident occurrences. The actual definition can varies from one country to another which is usually based on the frequency and severity of accident.

The basic definition for accident blackspot in Malaysia is as follows:

1. 5 or more accidents of various collision types that occur within a radius of 50 m during a period of 3 years or;
2. 3 or more accidents of a single collision type that occur within a radius of 50 m during a period of 3 years.

For the purpose of prioritisation, the number of accident is further analysed by considering the severity of the accident (fatal, serious, slight and damage). Rating points are given for each type of accident severity which are as follows:

1. Fatal = 6
2. Serious injury = 4
3. Minor injury = 2
4. Damage only = 1

The points given to the type of accident severity is actually related to 6 major cost components shown in the table below.

By multiplying the number of accident of each accident site with the respective severity rating point, total computed points are used as the basis for prioritisation. Implementation of accident countermeasures are focused on accident sites with the most points in the list of accident prone sites.

To limit the list of accident blackspots, accident sites with a total rating point of 15 or more are being considered.

Table E13: Severity Cost Components

Severity	Vehicle Damage	Medication	Hospital Bill	Pain & Suffering	Total loss to nation	Total loss to family	Total Points
Fatal	yes	yes	yes	yes	yes	yes	6
Serious injury	yes	yes	yes	Yes			4
Minor injury	yes	Yes					2
Damage only	yes						1

Source: Highway Planning Unit

Road Safety

New Ranking System for Blackspots

In the effort to improve the existing prioritisation process, Highway Planning Unit of the Ministry of Works Malaysia (HPU) proposed a new ranking system of accident locations that take into account three important factors. These factors are:

a. the accident site has higher number of accident than expected,
b. the yearly weightage, and
c. the accident severity recorded.

The first factor is the refining of the ranking accident sites by the method of averages or 'norm'. Before embarking on an in-depth study at any accident site, it is advisable to check that the site has higher numbers of accident than might be expected. The method involves some simple statistical analysis.

A particular route under consideration is first divided up into equal length (say, in kilometres) and the average number of accidents per section is then calculated. This is referred to as the arithmetic mean or norm. From the results of simple descriptive statistics, its mean number of accidents and its standard deviation can be calculated.

Hence, according to this method of norms, those sites that have more accidents than the mean plus one standard deviation will be among the first to be singled out for study or investigation. Therefore, accident sites greater than the total value of mean plus one standard deviation would be significant and as a result, the identified worst accident sites will be smaller.

Example:
Criteria to Exceed the Mean + S.D.

Mean + S.D. = 1.378276

For the site to be significant, the site should have accident frequencies of greater than Mean + S.D.
For all the fatal accidents in 1997, the
Mean + S.D. = 1.38

Therefore any site with fatal > 1.38 is considered significant (fatal >= 2). Hence it must equal or exceed HPU weighted points of 12 (2 fatal x 6 point).

The second factor takes into account of the more recent accidents as more heavier or higher percentage. Hence if the three year accident data from years 1995 to 1997 is taken, the proportion of significance applied in term of percentage as follows:

1st (1997) Year = 45%
2nd (1996) Year = 35%
3rd (1995) Year = 20%

The nearer the year of accident occurrence is to the compilation date of ranking, the higher is the weightage given. Accident data are grouped based on their year of occurrence. Accident points are then calculated for each group using the point system mentioned earlier. The total accident point will be the sum of weighted group points.

Road Safety

Accident Prevention - Road Safety Audit

The overall number and severity of accidents can be reduced through road engineering and traffic management initiatives under the following strategies:

Accident Prevention - application of remedial measures preventing accidents from taking place in the future. Techniques such as Road Safety Auditing, improved road design and traffic management with a more explicit consideration of road safety objectives, which is a pro-active approach; and

Accident Reduction - measures taken to reduce the number and severity of accidents. Involved techniques such as accident 'Blackspot' identification and treatment, including 'mass treatment' works, which is a 'reactive' approach.

Road Safety Audit
This is an accident prevention process which is a pro-active approach in an accident investigation.

A Road Safety Audit (RSA) is the formal examination of an existing or future road or traffic project by an independent team of trained specialists. Its main objective is to address the safe operation of a roadway and to ensure a high level of safety for all road users. The processes of the RSA stages are shown as per figure 1-5.

Table E14: Stages of RSA

Audit Stage 1:	Planning and Feasibility Study
Audit Stage 2:	Preliminary Design
Audit Stage 3:	Detail Design
Audit Stage 4:	During Construction
Audit Stage 5:	3 - 6 months after CPC/Existing Road

Audit Stage 4
Safety audit during this stage is conducted in 3 parts as described below:
Part 1 - Verification Audit of Construction Drawings
Part 2 - Audit when 50% of works completed
Part 3 - Audit prior to opening
Additional Audit every 3 months - limited to traffic management

The RSA team assesses the crash potential and safety performance of a roadway project and prepares a report that identifies potential safety problems. RSAs can identify deficiencies before they are built into the project and espouse quality improvement by building in safety from the beginning. Project officials or managers can then evaluate, select and justify appropriate project changes.

Qualification of Road Safety Auditor
A qualified Road Safety Auditor shall be an engineer that have a good understanding of the Driver / Vehicle / Road Environment interaction and have experience in accident investigation and countermeasures. He shall also fulfil the following requirements:

1. Ten (10) years working experience or six (6) years working experience with post graduate qualification.
2. Three (3) years road design experience and three (3) years of road safety engineering.
3. Must be a professional engineer registered with the Board of Engineers Malaysia.
4. Attended the full training course in RSA organized by JKR Malaysia or other related road agencies and it is mandatory for the applicant to pass all tests during the course.

Road Safety

Road Safety Audit Stage 1 & 2

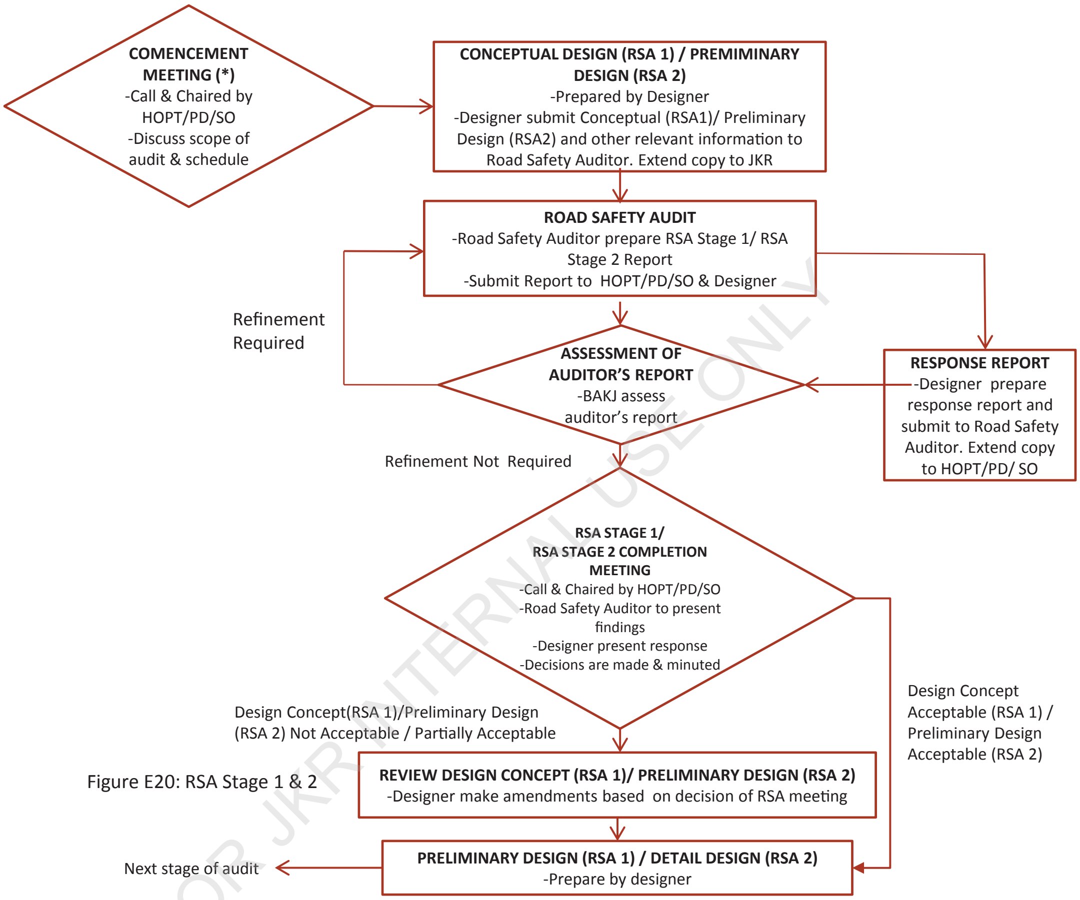


Figure E20: RSA Stage 1 & 2

Notes :

i) HOPT - Bahagian Pengurusan Projek (Cawangan Jalan)
ii) P.D - Project Director
iii) S.O - Superintending Officer
iv) BAKJ - Bahagian Audit Keselamatan Jalan (Cawangan Jalan)
v) (*)Commencement meeting can be conducted at other stages (if necessary)
vi) All copies of audit reports to be extended to BAKJ for monitoring and record purposes

Road Safety

Road Safety Audit Stage 3

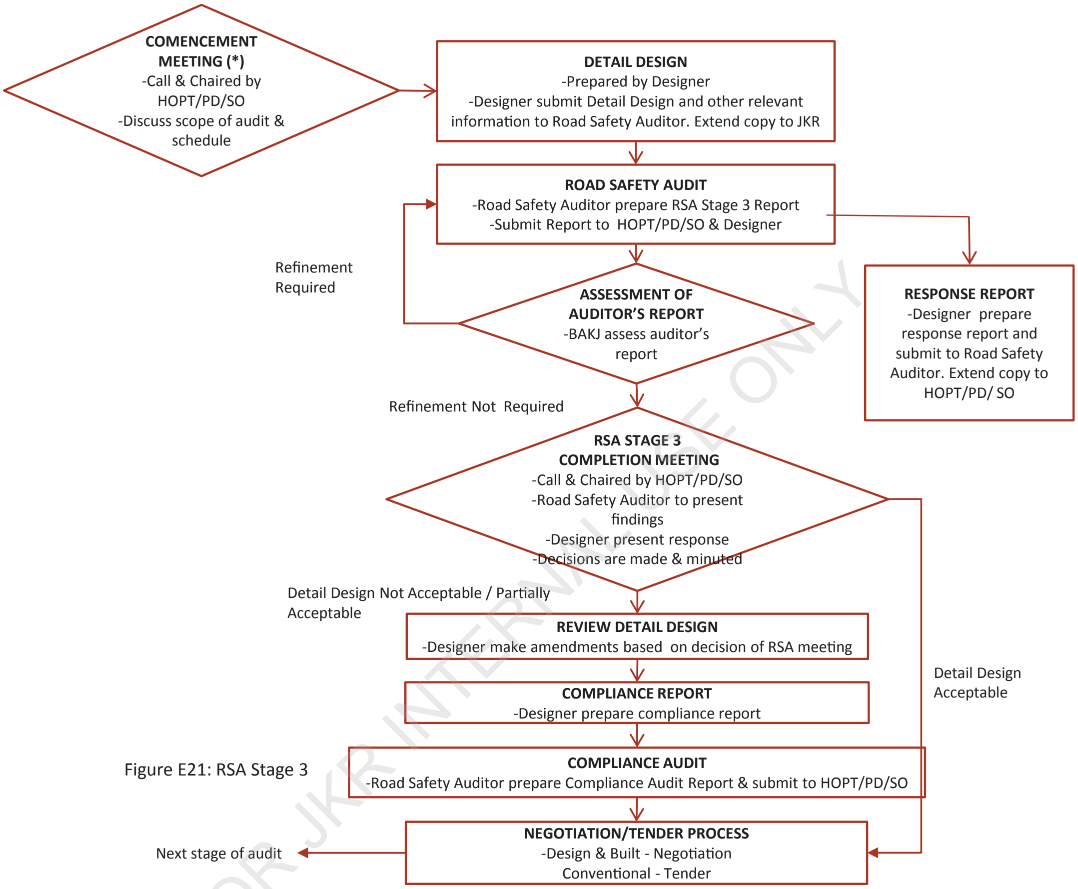


Figure E21: RSA Stage 3

Notes :

i) HOPT - Bahagian Pengurusan Projek (Cawangan Jalan)
ii) P.D - Project Director
iii) S.O - Superintending Officer
iv) BAKJ - Bahagian Audit Keselamatan Jalan (Cawangan Jalan)
v) (*)Commencement meeting can beconducted at other stages (if necessary)
vi) All copies of audit reports to be extended to BAKJ for monitoring and record purposes

Road Safety

Road Safety Audit Stage 4 (Part 1)

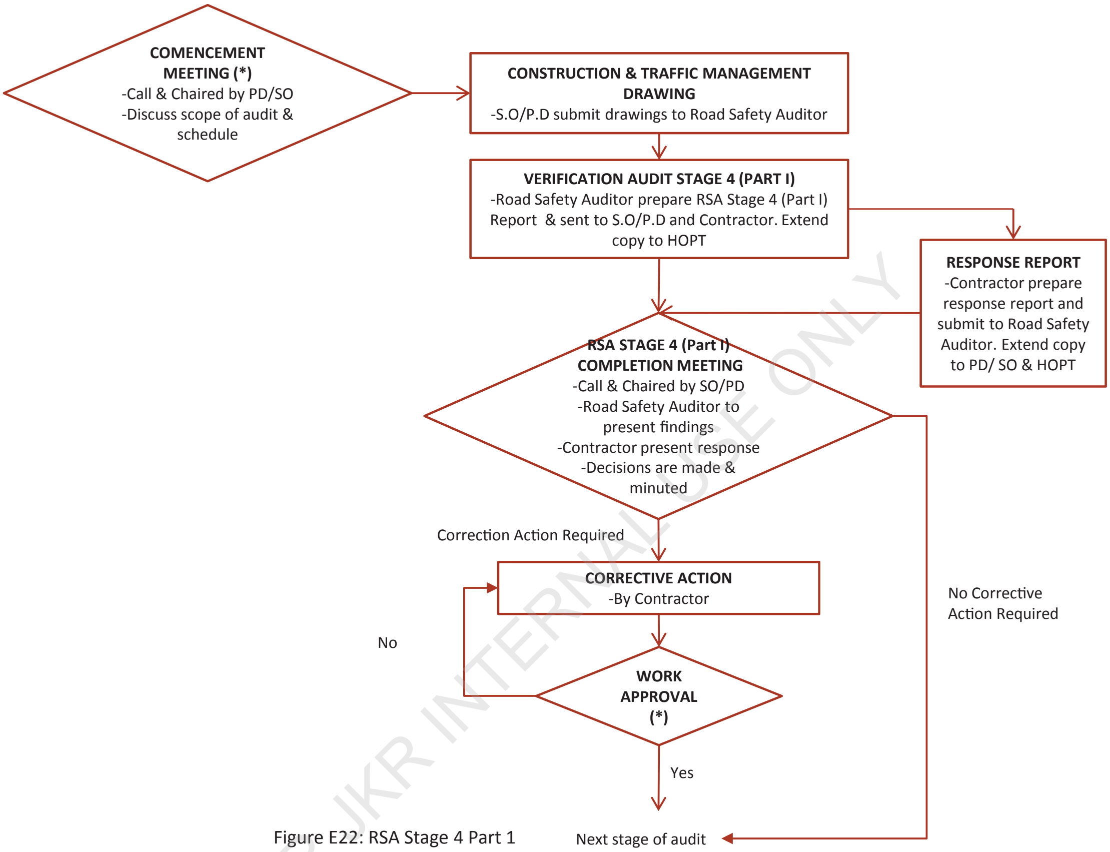


Figure E22: RSA Stage 4 Part 1

Notes :

i) HOPT - Bahagian Pengurusan Projek (Cawangan Jalan)

ii) P.D - Project Director

iii) S.O - Superintending Officer

iv) BAKJ - Bahagian Audit Keselamatan Jalan (Cawangan Jalan)

v) (*)Supervion Team need to ensure comments/recommendations by Road Safety Auditor is adhered by Contractor

vi) All copies of audit reports to be extended to BAKJ for monitoring and record purposes

Road Safety

Road Safety Audit Stage 4 (Part 2 & Part 3)

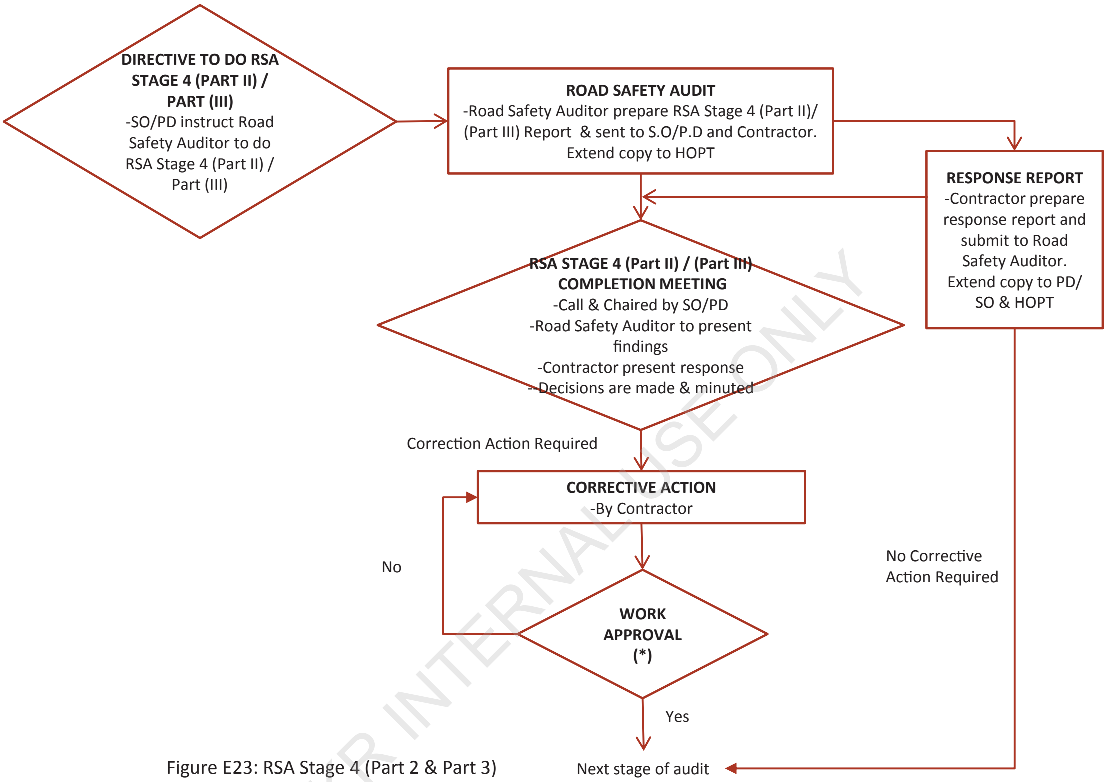


Figure E23: RSA Stage 4 (Part 2 & Part 3)

Notes :

i) HOPT - Bahagian Pengurusan Projek (Cawangan Jalan)

ii) P.D - Project Director

iii) S.O - Superintending Officer

iv) BAKJ - Bahagian Audit Keselamatan Jalan (Cawangan Jalan)

v) (*)Supervion Team need to ensure comments/recommendations by Road Safety Auditor is adhered by Contractor

vi) All copies of audit reports to be extended to BAKJ for monitoring and record purposes

Road Safety

Road Safety Audit Stage 5

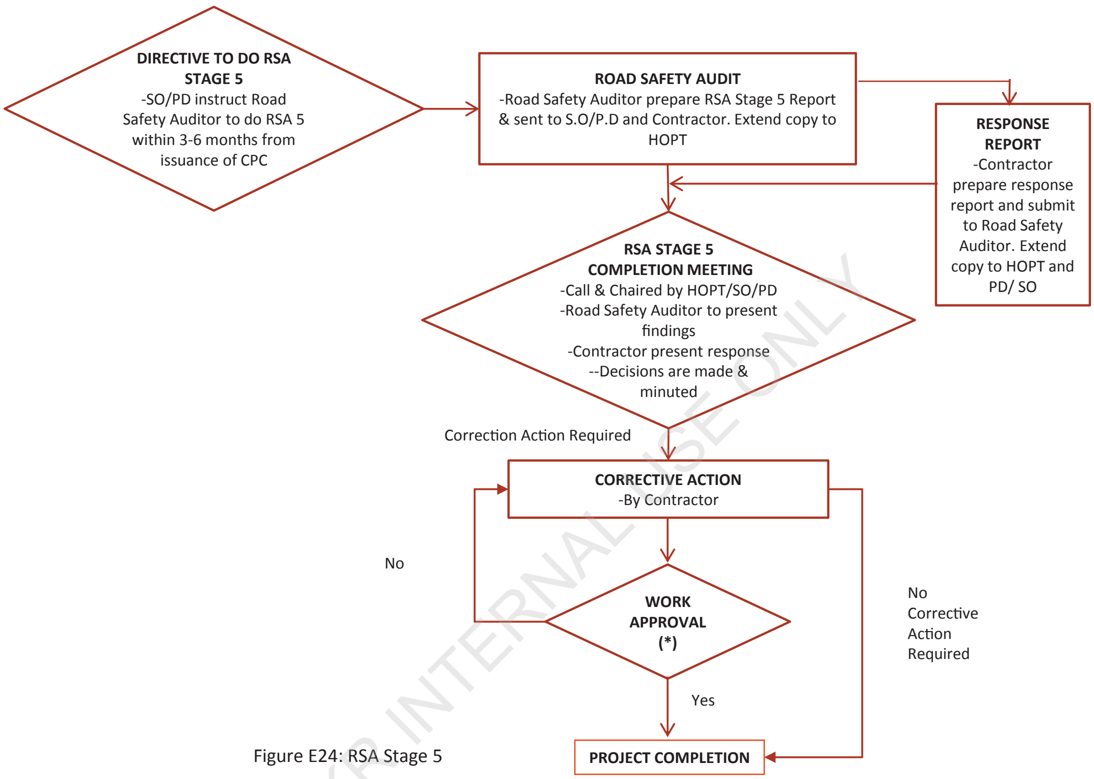


Figure E24: RSA Stage 5

Notes :

i) HOPT - Bahagian Pengurusan Projek (Cawangan Jalan)
ii) iP.D - Project Director
iii) S.O - Superintending Officer
iv) BAKJ - Bahagian Audit Keselamatan Jalan (Cawangan Jalan)
v) (*)Supervion Team need to ensure comments/recommendations by Road Safety Auditor is adhered by Contractor
vi) All copies of audit reports to be extended to BAKJ for monitoring and record purposes

Road Safety

Accident Reduction - Blackspot Eradication

There are 4 investigative techniques (listed below) used under the accident reduction strategy. The selection of appropriate technique will depend on the types and distribution of accidents, the land used distribution and, perhaps most importantly, the amount of remedial work already carried out.

- **Single sites / Blackspots**
  The treatment of specific types of accident at single location. Usually these are junctions, but could be areas 200 - 400m in diameter or 300 - 500m stretches of road.

- **Mass Action Plans**
  The application of a remedy to locations with a common accident problem such as skidding on wet surface, head-on collisions or accident involving crossing pedestrian.

- **Route Action Plans**
  The application of remedies along a route with a high accident rate.

- **Area-wide Schemes**
  The application of various treatments over a wide area of town / city. This may include traffic management and traffic calming in areas bounded by links on a network, housing areas or 1 km squares having higher accidents than a pre-set level.

Blackspot Eradication Program

This is one of the common program under the accident reduction strategy which involved a rigorous process of accident investigation and diagnosis before selecting and implementing the recommended countermeasures.

There are 10 steps in the process of reducing accident at any particular accident prone location. The flow chart consisting these steps is shown below.

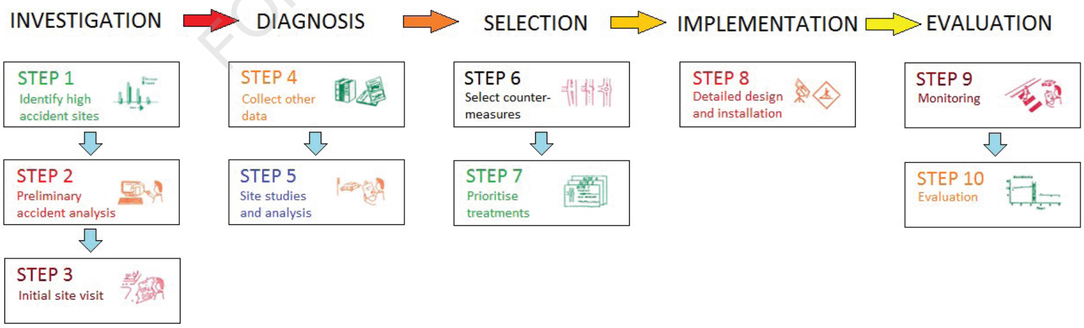


Figure E25: Steps under the Blackspot Eradication Process

Road Safety

Road Safety Auditor and Traffic Management Audit

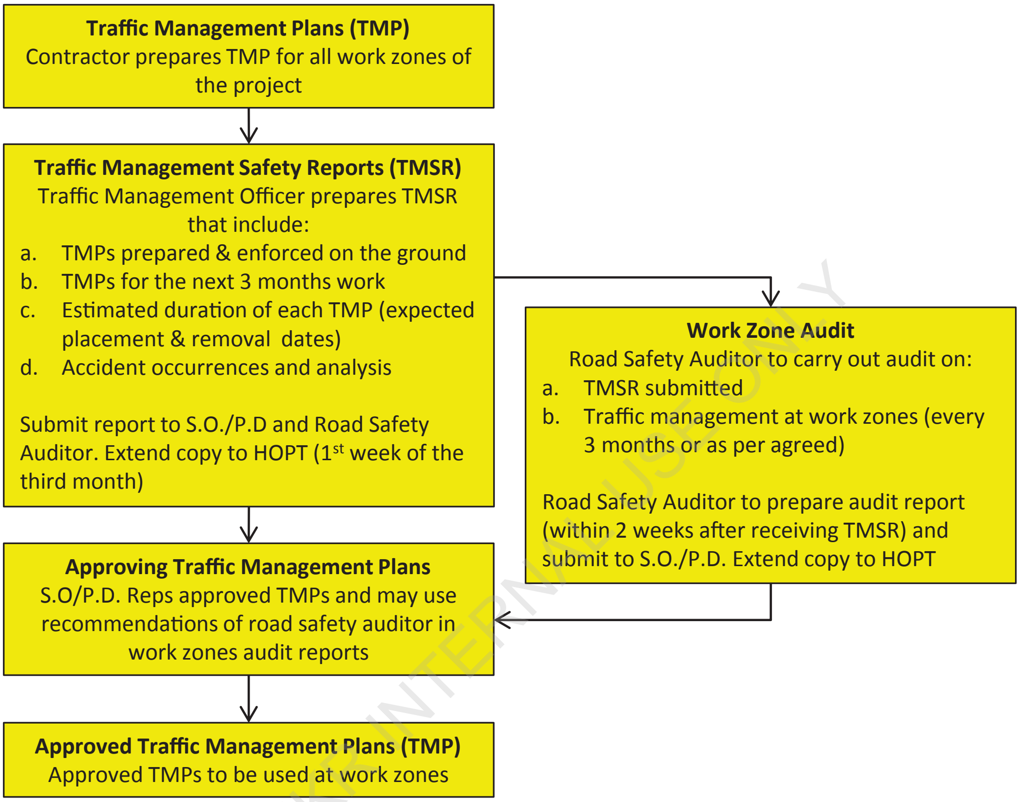


Figure E26: Flow Chart for Traffic Management Audit

Role of Road Safety Auditor

The role of the Road Safety Auditor in a road work zone is to generally audit the activities of road safety within the construction site. This includes the observation of the effectiveness of the TMPs and the devices employed during the night. The role of the Road Safety Auditor includes:

- Auditing the TMPs during the Design Phase
- Auditing the work zones during the Construction Phase. This is to be carried out as required by the S.O.
- Preparing reports and submit to the relevant authorities

Project Work Zone Audit Reports

The Road Safety Auditor will be required to audit the Traffic Management at the work zones as required by the S.O. Preferably, the audit should be done immediately after receipt of the TMSR from the Contractor. The Audit Report is to be submitted within 2 weeks after receiving the TMSR.

Road Safety

Road Safety Officer, TMP, and TMSR

Role of Project Road Safety Officer

The role of the contractor's Road Safety Officer is to ensure that the activities of road safety within the construction site follows the requirements of the Arahan Teknik (Jalan) 2C/85, "Temporary Signs and Work Zone Control". The duties are:

- Designing the TMPs
- Monitoring the placements and removals of the traffic control devices
- Monitoring the operations of the traffic control devices and equipment
- Maintain the effectiveness of the traffic control plans
- Analyse the occurrences of road accidents within the work zones
- Preparing and displaying the up-to-date TMP for inspection and audit
- Preparing the three monthly Traffic Management Safety Report (TMSR)

All these requirements must be met through the activities of design, placement, operation and maintenance.

Traffic Management Plans (TMP)

Traffic Management Plans are required for all Work Zones of the project. Each work zone will have a specific TMP with a specific reference number to it. These TMPs shall have reference numbers and are to be displayed for easy access during the inspections and audits visits. Whenever there is a change of traffic management on the site, these must be reflected in the TMPs being displayed.

The TMPs will have to be approved by the Supervising Engineers. A copy of the approved TMP shall be forwarded to the S.O. for final approval and acceptance.

Traffic Management Safety Reports (TMSR)

The Traffic Management Safety Reports (TMSR) are essential documents in the execution of the project. These reports are to be prepared by the Road Safety Officer and shall include the following:

- TMPs prepared and enforced on the ground.
- TMPs for the next three months' work.
- Estimated duration of each TMP (Placement dates and expected removal dates) are required.
- Accident occurrences and analyses.

The TMSR must be submitted by the first week of the third month to:

- the Supervising Consulting Engineer
- the S.O.
- the Bahagian Audit Keselamatan Jalan, PKJJ, Caw.Jalan.
- Bahagian Pengurusan Projek, Caw. Jalan
- the Road Safety Auditor

Project Work Zone Audit Reports

The Road Safety Auditor will be required to audit the Traffic Management at the work zones as required by the S.O. Preferably, the audit should be done immediately after receipt of the TMSR from the Contractor. The Audit Report is to be submitted within 2 weeks after receiving the TMSR.

ROAD TRAFFIC

Road Traffic

Road Traffic Volume Malaysia (RTVM)

The benefits of RTVM are as follows:

- Provides proper road network planning and roadside development
- Provides detailed study on the traffic flow criteria
- Provides current traffic information for research and study
- Provides comprehensive overview about the current road capacity
- Provides current Level of Services (LOS) of the respective roads.
- Provides information on the traffic growth and projection of traffic

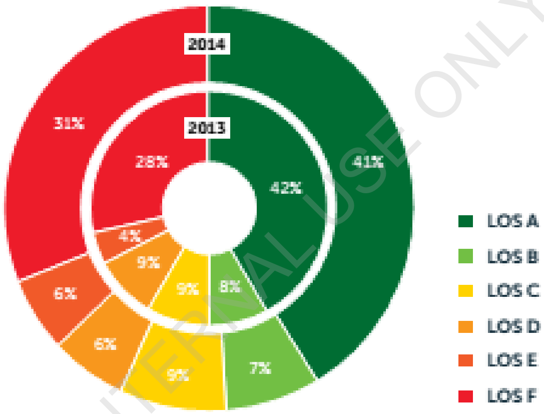


Figure F1: Distribution of Level of Services (LOS) of the Road at the 554 Census Stations in 2013 & 2014

LEVEL OF SERVICES (LOS)

Level of Services (LOS) are qualitative measures that describe traffic conditions in terms of speed, travel time, freedom to manoeuvre, comfort, convenience, traffic interruption and safety. LOS A represents the best condition, while LOS F represents heavily congested flow with traffic demands exceeding highway capacity.

By referring to the National Traffic Census 2014, Figure 1-3 shows that 31% of the roads in 2014 at the 554 census stations is already saturated (LOS F). The percentage increased 3% compared to the previous year. The percentage of roads with LOS E also increased compared to previous year. In contrast, the percentage of roads with LOS A, B and D in 2014 decreased from 2013. Meanwhile the percentage of roads with LOS C remains the same. These shows that the Level of Services (LOS) of these roads getting worse due to the increase of traffic volume at the particular roads.

Road Traffic

Traffic Census and Vehicle Classification

The National Traffic Census is carried out twice a year during the months of March/ April and September/ October, conducted by the State Public Works Department (JKR Negeri) and coordinated by Highway Planning Division. The census data will be submitted to Highway Planning Division for further data analysing and processing.

Data collections are divided into three types as Figure F1:

Figure F2: Types of Data Collection Method The vehicles are classified into six classes as shown in Table F1.

Class 1 Motor Cars and Taxis
Class 2 Small Vans and Utilities (Light 2-axles)
Class 3 Lorries and Large Vans (Heavy 2-axles)
Class 4 Lorries with 3-axles (Heavy 3-axles and above)
Class 5 Buses
Class 6 Motorcycles and Scooters

Table F1: Classes of Vehicles

CLASS	VEHICLE TYPE
Motorcars , Taxis & Small MPV's 1	 Small MPV's :- Proton Ixora,Produa Alza, Honda Stream, Toyota Wish, Naza Ria, etc.
Small Vans, Big MPV's & Utilities (Light 2 axles) 2	 Big MPV's :- Toyota Alphard/Vellfire, etc.
Lorries & Large Vans (Heavy 2 axles) 3	 Large Vans :- 12 Seater and Above
Lorries with 3 axles (Heavy 3 axles and above) 4	
Buses 5	
Motorcycles & Scooters 6	 Including 3 Wheel Motorcycle

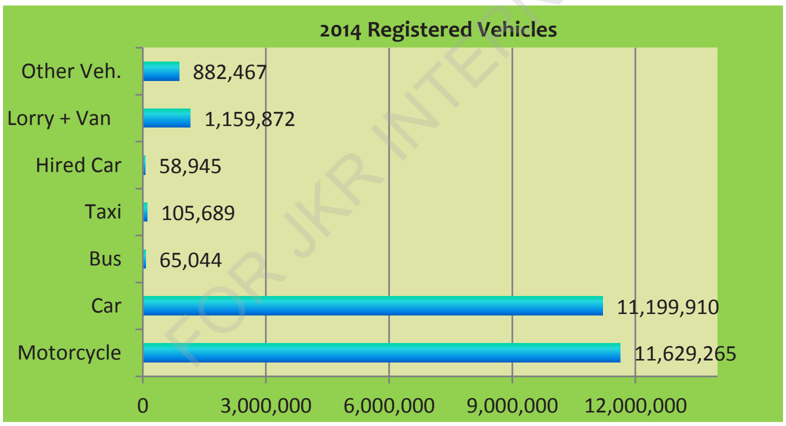
Road Traffic

Registered Vehicles and Drivers

Table F2: Registered Vehicle and Drivers

Year	Registered Vehicles (Type of Vehicle)								Number of Registered Drivers
	Personal		Public Transport (Bus + Taxi)			Trade	Other Veh.	Total	
	Motorcycle	Car	Bus	Taxi	Hired Car	Lorry + Van			
2005	6,977,469	6,426,457	57,071	67,154	11,674	802,913	390,847	14,733,585	9,928,238
2006	7,458,128	6,941,996	59,991	70,409	11,638	836,579	411,911	15,790,652	10,351,332
2007	7,943,364	7,419,643	62,308	72,374	12,368	871,234	432,652	16,813,943	10,769,531
2008	8,487,451	7,966,525	64,050	90,474	15,446	909,243	454,158	17,987,347	11,227,144
2009	8,905,854	8,461,334	66,201	78,841	16,579	936,222	471,941	18,936,972	11,697,306
2010	9,368,454	9,017,613	68,666	83,712	18,300	966,177	493,451	20,016,373	12,236,254
2011	9,947,189	9,675,397	71,628	89,815	19,194	997,649	515,867	21,316,739	12,763,452
2012	10,544,578	10,294,024	73,277	92,819	19,296	1,032,004	539,849	22,595,847	13,303,843
2013	10,926,125	10,355,037	62,182	98,513	53,775	1,112,480	861,154	23,469,266	13,803,023
2014	11,629,265	11,199,910	65,044	105,689	58,945	1,159,872	882,467	25,101,192	-

Figure F3



Source: POLIS DIRAJA MALAYSIA

Motorcycle remained as the popular mode of travel for the Malaysian public. The number of registered motorcycle is slightly more than the number of registered passenger car by as much as half a million.

Road Traffic

Average Daily Traffic (ADT) at 63 Locations, Peninsular Malaysia, 2010-2014

The following tables are traffic censuses from 2010 till 2014 that have been carried at 63 locations along the major Federal roads in Malaysia. The censuses are tabulated for each state together with the station no. and the name of the route.

Table F3(i)

No	Station	Route No	KM	Location	2010	2011	2012	2013	2014
PERLIS									
1	RR105	7	3.5	Kangar - Alor Star (Seriab)	21,758	23,234	25,577	26,155	25,092
KEDAH									
2	KR202	1	20.6	Alor Star - Changlun	30,402	32,311	42,822	47,474	34,003
3	KR401	1	70.8	Alor Star - Sungai Petani - Butterworth (Bumbong Lima)	24,002	22,195	23,141	23,971	23,672
4	KR501	1	29.0	Alor Star - Sungai Petani (Bt. 18 Guar Chempedak)	19,387	19,618	19,249	18,853	17,797
PULAU PINANG									
5	PR116	1	16.9	Butterworth - Taiping	56,349	60,230	56,932	64,993	48,588
6	PR201	6	11.1	George Town - Telok Bahang (Jalan Keliling Pulau)	27,334	26,085	28,442	27,106	28,419
7	PR203	6	57.2	George Town - Bayan Lepas - Gelugor	50,776	50,950	59,900	6.19	0.9638
PERAK									
8	AR101	1	106.6	Ipoh - Tanjong Malim (Slim River toll house)	15,323	14,039	14,431	15,328	16,501
9	AR204	5	78.9	Ipoh - Lumut	22,389	23,758	25,283	25,942	23,834
10	AR301	1	35.9	Ipoh - Kampar (near S.M. Kampar)	31,022	30,311	27,497	28,520	27,126
11	AR303	1	5.6	Ipoh - Gopeng	84,135	73,487	85,819	77,195	78,210
12	AR501	1	30.4	Ipoh - Kuala Kangsar (Hospital Sg. Siput)	19,426	22,500	19,251	20,478	18,578
13	AR601	1	82.1	Changkat Jering - Semanggol	14,128	3,379	19,410	20,588	19,881
14	AR603	60	96.6	Ipoh - Batu Hampar - Changkat Jering	10,270	18,646	12,586	12,938	12,531
15	AR703	5	106.3	Ipoh - Telok Intan - Simpang Empat	25,365	25,004	28,465	25,489	25,865
16	AR801	76	40.0	Kuala Kangsar - Baling	1,724	3,110	3,562	3,487	2,826
17	AR803	4	2.4	Lebuhraya Timur - Barat	3,337	3,148	3,944	3,796	3,636

Road Traffic

Average Daily Traffic (ADT) at 63 Locations, Peninsular Malaysia, 2010-2014

Table F3(ii)

No	Station	Route No	KM	Location	2010	2011	2012	2013	2014
SELANGOR									
18	BR102	2	3.5	Klang - Port Klang (Persiaran Raja Muda Musa)	52,901	53,983	57,835	56,513	52,563
19	BR108	20	6.0	North Klang Straits Bypass (300m from junction Federal Highway)	141,121	135,678	140,780	143,223	128,676
20	BR203	5	48.3	Klang - Morib - Batu Laut	7,101	6,852	7,128	7,777	7,741
21	BR405	54	45.1	Kuala Lumpur - Kepong - Kuala Selangor	22,822	23,003	23,648	21,278	22,618
22	BR501	5	72.1	Klang - Sabak Bernam	20,466	21,743	23,370	22,174	22,443
23	BR604	1	21.7	Kuala Lumpur - Kajang - Telok Datok (Bt. 14 Jalan Cheras)	56,609	57,591	53,689	59,023	54,222
24	BR701	1	58.6	Kuala Lumpur - Kuala Kubu Bahru Junction (south of junction)	18,293	13,430	13,320	15,082	15,022
25	BR902	28	14.1	Jalan Lingkaran Tengah 2 (MRR2)	129,345	144,334	151,486	147,449	144,308
W.P. KUALA LUMPUR									
26	WR101	54	8.9	Kuala Lumpur - Kuala Selangor (Jalan Kepong)	153,564	136,860	139,737	160,694	132,401
27	WR102	1	12.1	Kuala Lumpur - Ipoh	277,797	276,092	252,341	253,179	214,760
28	WR103	1	8.1	Kuala Lumpur - Ipoh	196,796	209,224	203,277	216,424	192,223
NEGERI SEMBILAN									
29	NR304	53	10.2	Seremban - Port Dickson (Lukut)	65,580	46,201	54,394	59,864	62,112
30	NR403	1	41.7	Seremban - Tampin		12,565	12,832	12,645	11,459
31	NR501	1	20.0	Seremban - Kuala Lumpur (Old road)	12,052	11,964	11,397	10,671	11,810
32	NR505	1	9.3	Seremban - Gemas (Sri Sen-awang Industrial Area)	35,708	38,378	57,639	50,484	48,002
MELAKA									
33	MR206	5	22.9	Jalan Melaka - Muar		16,426	17,044	16,779	17,112
34	MR301	19	25.0	Lebuh AMJ (Alor Gajah - Kendong)	11,472	11,465	11,170	15,715	15,665
35	MR313	5	43.5	Jalan Melaka - Masjid Tanah - Lubok China	7,858	8,084	8,480	9,097	9,013

Road Traffic

Average Daily Traffic (ADT) at 63 Locations, Peninsular Malaysia, 2010-2014

Table F3(iii)

No	Station	Route No	KM	Location	2010	2011	2012	2013	2014
JOHOR									
36	JR101	5	142.0	Batu Pahat - Muar	11,162	11,711	14,847	18,659	15,491
37	JR104	24	127.2	Yong Peng - Muar	25,916	40,092	23,361	34,672	32,757
38	JR108	1	116.0	Johor Bahru - Segamat	12,262	13,025	12,369	11,628	11,521
39	JR205	1	9.0	Johor Bahru - Ayer Hitam	221,084	213,390	162,454	189,292	191,427
40	JR218	17	35.0	Johor Bahru - Masai (1km east junction to Masai)	49,309	40,428	47,563	26,552	26,502
41	JR305	1	77.3	Johor Bahru - Ayer Hitam	14,810	14,894	15,398	13,911	15,847
42	JR306	50	49.1	Batu Pahat - Ayer Hitam - Kluang	34,964	36,952	39,674	38,053	38,366
43	JR404	3	38.6	Johor Bahru - Kota Tinggi	20,302	20,106	23,273	22,103	19,750
44	JR501	3	135.0	Johor Bahru - Endau (2.4km north of Mersing town)	15,598	13,445	13,411	14,412	14,391
45	JR503	3	111.0	Johor Bahru - Kota Tinggi - Jemaluang (500m south of Jemaluang)	4,633	4,481	4,490	4,720	4,381
46	JR702	5	66.5	JB - Pontian Kechil - Pontian Besar (near Hospital)	14,406	12,125	16,772	15,061	14,678
47	JR801	1	200.0	Johor Bahru - Segamat - Batu Enam	15,237	15,781	15,875	16,826	16,800
PAHANG									
48	CR102	2	68.1	Kuala Lumpur - Kuantan (KL - Karak Highway)	28,109	27,653	28,470	26,509	28,300
49	CR403	2	27.0	Kuantan - Maran	28,248	29,142	31,138	31,416	31,876
50	CR410	3	30.5	Kuantan - Kemaman (Sg. Ular)	22,079	23,278	22,911	21,601	22,995
51	CR503	8	282.0	Kuala Lumpur - Kuala Lipis - Kampong Padang Tuanku -	6,253	7,053	7,513	6,985	7,319
Kota Bahru									
52	CR603	3	48.0	Pekan - Nenasi (in front of JKR Pekan)	8,650	9,761	10,319	11,563	11,535
53	CR801	2	115.0	Kuantan - Karak	11,771	11,597	13,281	13,328	15,673
54	CR805	2	70.9	Kuantan - Maran (Kg. Luit)	6,890	7,317	7,088	6,952	6,714
55	CR902	12	102.2	Kuantan - Segamat (400m Bkt. Ibam - Rompin junction north bound)	8,102	8,427	9,545	8,763	9,314

Road Traffic

Average Daily Traffic (ADT) at 63 Locations, Peninsular Malaysia, 2010-2014

Table F3(iv)

No	Station	Route No	KM	Location	2010	2011	2012	2013	2014
TERENGGANU									
56	TR103	3	62.0	Kuala Terengganu - Jerteh - Kota Bharu	24,196	25,551	27,325	27,066	19,490
57	TR202	3	80.2	Kuala Terengganu - Dungun - Kemaman (Kuala Dungun - Paka)	28,602	30,035	27,856	29,864	28,124
58	TR305	14	48.0	Cheneh - Kuala Terengganu (Jalan Jabor - Jerangau)	5,590	6,553	7,566	8,036	7,667
59	TR402	3	17.0	Kuala Terengganu - Marang	25,887	27,451	29,532	31,227	31,686
60	TR502	14	146.0	Kuala Terengganu - Ajil - Jerangau	14,695	12,649	10,092	8,715	8,739
KELANTAN									
61	DR201	3	19.3	Kota Bharu - Pasir Puteh	31,602	37,939	42,433	32,263	26,043
62	DR603	4	6.1	Lebuh raya Timur - Barat	5,440	5,863	6,275	6,029	6,141
63	DR802	8	61.5	Kota Bharu - Kuala Krai	20,623	22,308	23,381	21,200	22,523

Road Traffic

Types of Traffic Survey

Traffic survey is the most basic of all traffic studies. The volume and its composition are important considerations in almost all aspect of traffic management. Conducted either manually or by automatic means, the survey are divided into several types based on their purposes.

Table F4: Types of Traffic Survey

Description	Types of Traffic Survey		
Census	**Bi-Annual Census**	**Permanent Survey**	**Ad-Hoc Traffic**
Period	1 - 7 days in March/ April & September/ October every year since 1967	Conducted on continuous basis since 2000	Conducted when the need arises, depending on type of analysis required
Survey Station	554 stations throughout Malaysia	20 stations scattered all over Peninsular Malaysia	Study Area
Method	Manual counting	Automatic devices known as Telemetric	Manual and Automatic Hi -Star devices..
Type of Data	Vehicle classification	Vehicle Classification Daily Traffic Volume Speed	Depends on nature of study
Survey Authority	HPU with the assistance of State and District PWDs	HPU	HPU with the assistance of State and District PWDs

ROAD SURVEY AND LAND ACQUISITION

Road Survey And Land Acquisition

Land Survey For Road Works

BASIC PROFESSIONAL LAND SURVEYING SERVICES FOR ROAD WORKS

The services to be rendered by the CLS include the provision of all expert technical advice and skills, which are normally required for the works for which the CLS has been engaged.

1.0 General

The services to be provided by the CLS as listed herein and as detailed in subsequent sections:

1. Prior discussion with relevant authorities such as JKR,PDRM, land office and local authorities before the physical commencement of work on site.
2. Study all relevant information and map provided and obtain additional data if necessary for the proper execution of the works.
3. Consultation with the GR and setting out.
4. Setting out of survey alignment.
5. Field of survey and picking up of mapping details for subsequent submission of 3 dimensional digital data in drawing (autocad) format.
6. Establishment of permanent ground makers for survey control such as survey markers, bench marks, and temporary bench marks.
7. Preparation of land acquisition bas plans in accordance to JKR guidelines (Arahan Teknik Jalan 7/85).
8. Preparation of plans in accordance to Arahan Teknik Jalan 6/85 or specified in the Term Of Reference.
9. Compilation, processing and preparation of data in accordance to 3D drawing format (Autocad).
10. Pegging of centreline for design road alignment and establishment of permanent ground makers for design road alignment centreline (Such as Ips, RMs and TBMs).

2.0 Fieldwork

1. Grid & Planimetric Control Accuracies
2. Height datum & vertical accuracies
3. Permanent Ground Makers
    - Intersection Point(
    - Reference Marks (RMs) :
    - The CLS shall erect at least two(2) RMs for each IP.
    - To ensure accuracy, RMs shall be placed at least 25m away from the IP.
    - Temporary Bench Marks (TBMs)
4. Survey of Watercourses eg. Streams & Rivers, Urban Drainage, Culverts,
5. Flood Information
6. Details of Junctions and Existing Roads
7. The CLS shall survey all junctions to enable the designer to design the junction properly. A corridor width of 40m and shall be taken for the distance of not less than 150m up and down the proposed intersection of the road or as required by Government. All metaled roads, main roads and footpaths or tracks having the greater than 2m shall have a minimum of two(2) points defining both edges of the carriageways.
8. Strip survey
9. The CLS shall carry out a strip survey with the contours at 2m intervals together with the detail of the strip.

Road Survey And Land Acquisition
Land Survey For Road Works

3.0 Mapping

Features to be shown :

1. Building / Structures
2. Boundary Features
3. Railways
4. Roads / Tracks / Footpaths
5. Road furniture
6. Industrial
7. Slopes and Earthworks
8. Services and Utilities
9. Survey control
10. Woods / Trees / Recreation Areas
11. Water / Drainage / Coastal features.
12. Contours
13. Spot Height
14. Bridge details
15. Culvert details

4.0 Preparation and submission of plans and data

The CLS shall provide the Government with two(2) sets of prints together with one(1) set of master transparency for all drawings prepared. The drawings required are as follows :

1. Location plan and Alignment Control Plan
2. Preliminary Survey Plans and Data
3. Final Survey Plans
4. Detail Plans for Bridges and Culvert sites
5. Plans for Junction or Site details
6. Land Acquisition Plans
7. Format of Drawings to be submitted
8. Format of Data to be submitted :
    - Format for Presentation : Unless otherwise specified in Terms Of Reference, all formats of drawings submitted including the title block shall conform to JKR Guidelines as contained in Arahan Teknik (Jalan) 6/85 (Guidelines For Presentation of Engineering Drawings). All drawings shall be to A1 size unless otherwise specified.
    - Final Drawings : All final drawing shall bear the name, signature and qualification of the CLs as well as the name and address of his company. Final drawings shall consist of two(2)set of paper print and if necessary further copies approved. One(1) set of readable / editable softcopy plans on compact disks (CDs) shall also be provided in Autocad 2000/2002.

5.0 Date submission of drawings and data

6.0 Field books and final survey report

All field books and computer data must be properly kept and shall record truthfully all the survey work carried out. The CLs shall do all workings in proper books, adequately in good style and according to best practice.

On completion of survey work, all field books, computer data shall be properly labelled and compiled and submitted to JKR and shall remain the property of the government. All field books and survey data , plans and drawings shall be duly certified by the CLs.

Road Survey And Land Acquisition
Guidelines On Land Acquisition Process

INTRODUCTION

1. DETERMINATION OF ROAD ALIGNMENT

For any upgrading projects, the proposed road alignment should be designed within the right of way (R.O.W) to minimize the project cost by reducing the required land acquisition.

For new projects, a study on several alternative alignments is required to determine the most cost effective choice. A site visit shall be arranged once the finalized alignment is determined.

2. NOTICE TO ACQUIRE LAND

Once the conceptual design of the road alignment is finalized, the proposed land acquisition plan is then prepared. The application for land acquisition is thus submitted to the associated state JKPTG/PTG to obtain the approval from the state local authority.

Once the approval is obtained, the associated state JKPTG/PTG will broadcast a public notice in the State Government Gazette through '*Borang A* bawah Seksyen 4 Akta Pengambilan Tanah 1960*'. (Borang A – to gazette notice that the land is probably going to be acquired)

3. AUTHORITY TO ENTER SURVEY AND CONDUCT PRELIMINARY WORKS

To begin with the survey, preliminaries, and other related works pertaining to the site, '*Borang B* bawah Seksyen 5 Akta Pengambilan Tanah 1960*' shall be prepared. The form together with the list of agents and required service provider is required to be submitted through the state JKPTG to obtain the approval from the state director.

4. PREPARATION OF LAND ACQUISITION PLAN

a. Plan Scale
b. Measurement System
c. Required Plan Details (Lampiran 3,4,5)
d. Search Certificate 'Sijil Carian Rasmi (Lampiran 6)'
e. Handing Over Plan (Lampiran 7)
f. Other requirements
g. Land acquisition through 'Sijil Perakuan Segera' (Borang I)

Note:

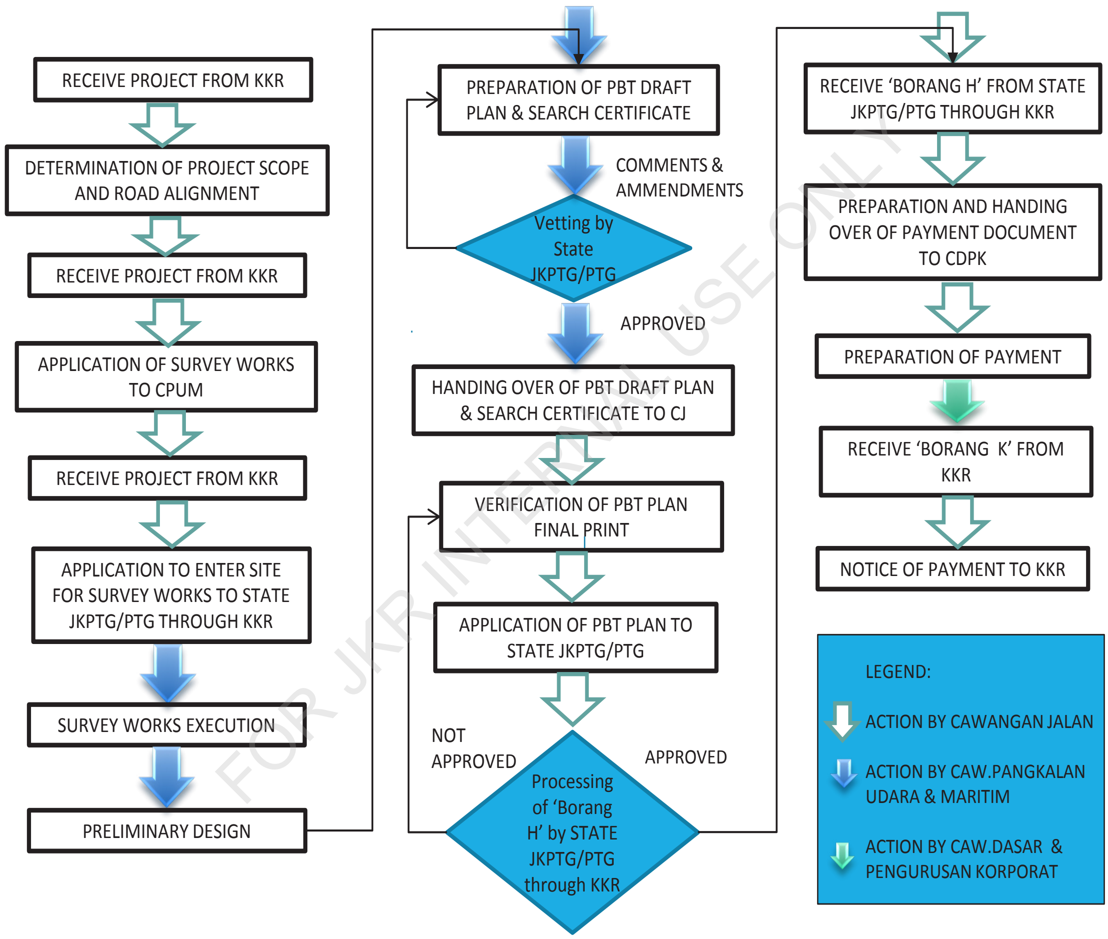
* ATJ 7/85 content shall be referred for Attachments and forms.

- *Sebagaimana diperuntukkan dalam perenggan 1(1)(a) Jadual Pertama Akta 486, notis pengambilan tanah melalui Borang A perlu disusuli dengan pengisytiharan melalui Borang D (*Declaration of Intended Acquisition*) dalam tempoh dua belas (12) bulan dari tarikh pewartaan yang pertama. Kegagalan mematuhi tempoh penyiaran warta susulan ini akan membawa implikasi kewangan kepada Kerajaan.*
- *Tarikh pewartaan pengambilan tanah adalah amat penting kerana ia menentukan nilai semasa tanah bagi tujuan bayaran pampasan yang perlu dibayar oleh PBN kepada pihak berkepentingan. Dalam hal ini, perenggan 1(1) Jadual Pertama Akta 486 memperuntukkan nilai pampasan yang perlu dibayar oleh PBN adalah berdasarkan harga pasaran (market value) tanah pada tarikh pewartaan menurut seksyen 4 yang disusuli dengan pewartaann menurut seksyen 8 Akta 486 <u>atau</u> pada tarikh pewartaan menurut seksyen 8 Akta 486.*

Road Survey And Land Acquisition

Organisation's Roles In The Land Acquisition Process

Flow Chart on involvement and roles of Ministry Of Works (KKR) and Public Works Department(JKR) In the Land Acquisition process.



• BORANG H

The application for land acquisition for a federal road project is through and will be executed by KKR. After the application of land acquisition has been gazetted under 'Seksyen 8 APT' and investigation on 'Seksyen 12' is concluded, the land administrator will produce 'Borang H' under 'Seksyen 16 Akta Pengambilan Tanah 1960'. 'Borang H' shall be the notice to inform on the offer for compensation. KKR will producem a copy of 'Borang H'. (Please refer to 'lampiran 8-list of forms to CJ for payment of compensation.)

• NOTICE OF PAYMENT

For payments made through cheque, CDPK will issue the cheque to the state JKPTG/PTG. If the payment is done through EFT, CDPK will inform the state JKPTG/PTG by email that the payment have been made to the land owner and a copy will also be sent to CJ for record purposes. The state JKPTG/PTG will require the information on the issued payment to proceed with the issuence of 'Borang K'.

Note:

In the event of the applying agency disputes the amount of compensation by the land administrator, only 75% of the compensation shall be paid and the rest of the amount will only be released once the court order is received if any.

• BORANG K

'Borang K' is a notice to inform that the land have been acquired under 'Seksyen 22 Akta Pengambilan Tanah' and the form will be sent to KKR which applied for the land acquisition.

Once 'Borang K' has been issued, this indicates that the land acquisition process is complete and the contractor can proceed to enter the project site and begin the construction works.

• PREPARATION OF COMPENSATION PAYMENT

STATE JKPTG / PTG OFFICE

RECEIVE 'BORANG H' FROM STATE JKPTG /PTG THROUGH 'BAHAGIAN PEMBANGUNAN & PENSWASTAAN,KKR'

CAWANGAN JALAN

Detail checking by CJ on the land area which has been approved and the area which was applied including the attached forms.

Supporting Documents Not Complete

Complete Documents & Borang H

BHG. KEWANGAN & AKAUN, CDPK

PAYMENT PROCESS
CDPK shall process the payment through EFT (electronic fund transfer)/ issuance of cheque for specific cases which is decided by the state JKPTG/PTG.

STATE JKPTG / PTG OFFICE

ISSUENCE OF PAYMENT
For payments by cheque, State JKPTG/PTG office is responsible to hand over the cheque to the rightful individual. For payments through EFT, the date of the voucher shall be recorded as the payment date.

BORANG-BORANG YG DIGUNAKAN DLM AKTA PBT 1960 (ACT 486)

BORANG A (S4) - NOTIS BAHAWA TANAH MUNGKIN PEROLEHI
BORANG B (S5) - KEBENARAN UNTUK MEMASUKI PENGUKURAN
BORANG C (S6) - JADUAL TANAH-TANAH YANG TERLIBAT DENGAN PEMEROLEHAN
BORANG D (S7) - PENGISTIHARAN PEMEROLEHAN YANG DICADANGKAN
BORANG E (S10) - PEMEROLEHAN YANG DICADANGKAN: NOTIS PENYIASATAN
BORANG F (S11) - NOTIS MENGHENDAKI KETERANGAN SECARA BERTULIS
BORANG G (S14) - ANUGERAH BERTULIS UNTUK PAMPASAN
BORANG H (S16) - NOTIS ANUGERAH DAN TAWARAN PAMPASAN
BORANG I (S19) - SURAT AKUAN SEGERA
BORANG J (S20) - NOTIS SUPAYA MENGOSONGKAN BANGUNAN
BORANG K (S22) - NOTIS BAHAWA PEMILIKAN TELAH DIAMBIL KE ATAS TANAH

ROAD DESIGN STANDARDS

Road Design Standards

Highway Planning and Design

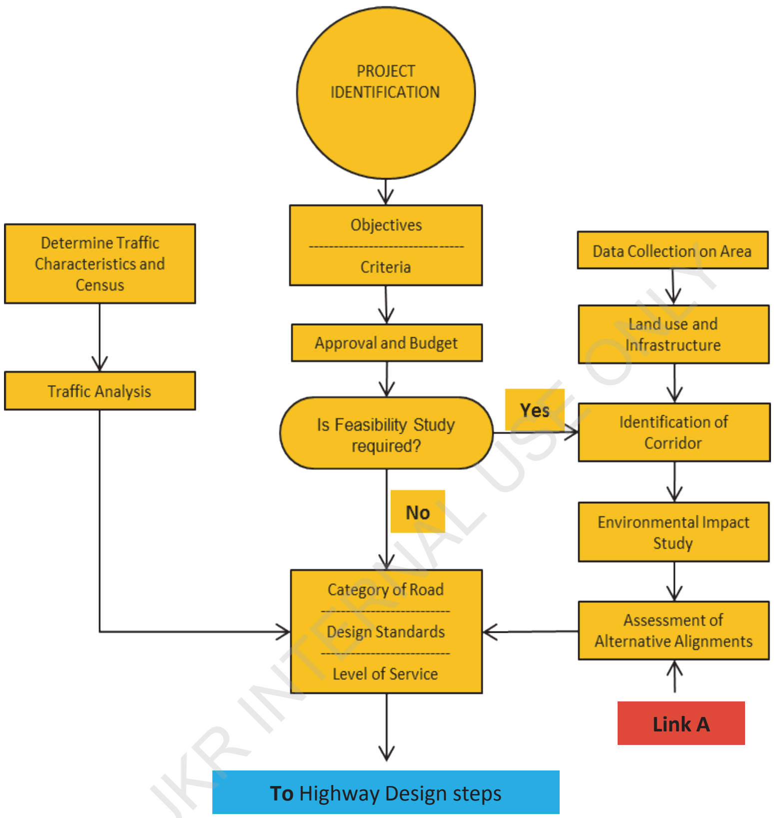


Figure G1: Highway Planning and Design

This flow chart is the first part of the process consisting of mainly Highway Planning steps.

There are many activities in road design process which starts with planning till the preparation of tender documents. However, this book does not cover every aspect of the design activities but focussed on those that are commonly referred by practitioners.

Some of the main activities of the detailed engineering design are as listed below. It should be noted that not all the activities listed may be applicable to a particular project and also they are not necessarily listed in the order of the actual execution of physical design.

1. Route relocation and preliminary ground survey
2. Selection of final alignment control
3. Horizontal alignment
4. Vertical alignment
5. Cross-sections & stability of slope
6. Intersection
7. Street lighting
8. Pavement
9. Lane markings
10. Road signs
11. Roadside furniture
12. Drainage
13. Traffic signal
14. Landscaping
15. Environmental impact
16. Construction Specifications

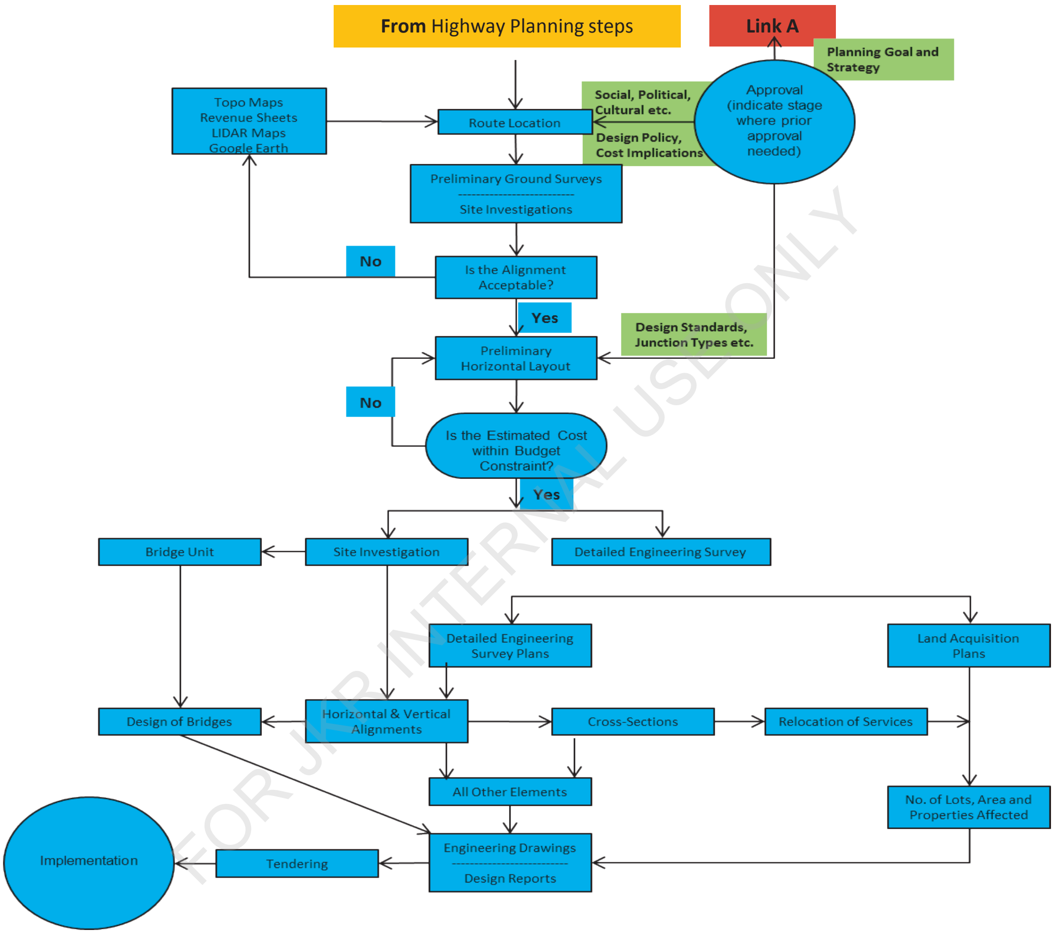


Figure G2: Highway Planning and Design
This flow chart is the second part of the process consisting of Highway Design steps.

Road Design Standards

Road Classification and Hierarchy

Roads are divided into two groups by area, i.e. rural and urban.

Function of Road
Each road has its function according to its role either in the

- National Network,
- Regional Network,
- State Network or
- City/Town Network.

The most basic function of a road is transportation. This can be further divided into two sub-functions; namely mobility and accessibility.

However, these two sub-functions are in trade-off. To enhance one, the other must be limited.

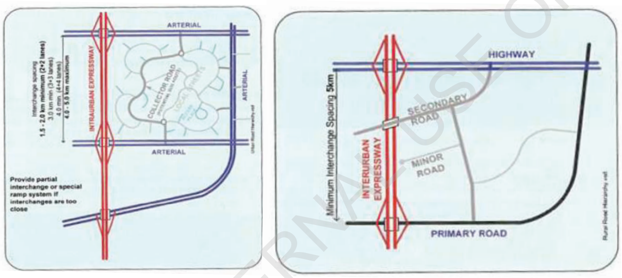


Figure G3: Functional Classification System - Urban & Rural Area

5 Category of roads in Rural Areas:

- Expressway,
- Highway,
- Primary Road,
- Secondary Road and
- Minor Road.

Mobility

Accessibility

4 Category of roads in Urban Areas:

- Expressway,
- Arterial,
- Collector and
- Local Street.

Mobility

Accessibility

They are in ascending order of accessibility but in descending order of mobility.

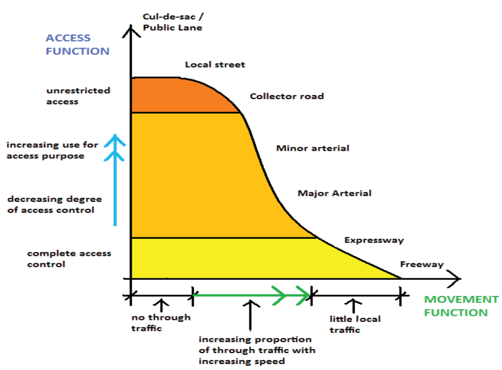


Figure G4: Chart of the Movement Function against Access function

Degree of Control

Access control is the condition where the right of owners or occupants of abutting land or other persons to access, in connection with a road is fully or partially controlled by the public authority. Control of access is usually classified into three types for its degree of control, namely full control, partial control and non-control of access

Full Control of Access

mean that preference is given to through traffic by providing access connecting with selected public roads only and by prohibiting crossings at grade or direct private driveway connections. The access connection to public roads varies from 2 km (for highly developed CBD) to 8 km or more (sparsely developed urban fringes). Full control of access means no driveways from adjacent properties are permitted except to a service road. Limited access means property access may be restricted by the construction of a median that only allow left turns into properties and left turns out. Criteria for the location of property access to new local streets include distance from intersections, sight distance required, and a possible requirement for vehicles not to reverse onto the road.

Partial Control of Access

means that preference is given to through traffic to a degree that in addition to access connection with selected public roads, there may be some crossings trafficked roads, at grade intersections should be limited and only allowed at selected locations. The spacing of at-grade intersections preferably signalised may vary between 0.4 to 1.0 km apart. To compensate for the limited access to fully or partially access controlled roads, frontage or service roads are sometimes attached to the sides of the main roads.

In Non Control Access, there is basically no limitations of access.

Road Design Standards

Level of Service

Table G1: Illustration of Level of Services (LOS)

	Level of Service	Remarks		Level of Service	Remarks
	A	Free flow. This is a condition of free flow with low volume and high speed of vehicle travel on he highways.		D	High density flow in which speed and freedom to maneuver are severely restricted and comfort and convenience have decline even though flow remain stable.
	B	Stable traffic flow with a high degree of freedom to select speed and operating condition but with some influence from the other users.		E	Unstable flow at or near capacity levels with poor levels of comfort and convenience.
	C	Restricted flow that remain stable but with significant interaction with others in the traffic stream. Most of the drivers are restricted in their freedom to select their own speed, change lane or pass.		F	Forced traffic flow in which the amount of traffic approaching a points exceeds the amount that can be served. It is characterizing by poor time travel, low comfort, convenience and increase accident exposure.

Level of Service

The concept of level of service relates to the operating conditions encountered by traffic. It is a qualitative measure of many factors. Six common levels of service are in terms of traffic service volumes (v/h/l - vehicle per hour per lane):

Road Design Standards

Design Level of Service and V/C Ratio

Table G2: Design LOS and VC Ratio for Rural Roads

Road Category (RURAL)	Design Level of Service	Volume / Capacity Ratio
Expressway	C	0.70 - 0.80
Highway	C	0.70 - 0.80
Primary Road	D	0.80 - 0.90
Secondary Road	D	0.80 - 0.90
Minor Road	E	0.90 - 1.00

Table G3: Design LOS and VC Ratio for Urban Roads

Road Category (URBAN)	Design Level of Service	Volume / Capacity Ratio
Expressway	C	0.80 - 0.90
Arterial	C	0.80 - 0.90
Collector	D	0.80 - 0.90
Local Road	E	0.90 - 1.00

The above tables show the proposed design level of service for rural and urban areas. The level of service is simplified into ranges of volume / capacity ratio for the purpose of design.

Rate of traffic service (service volume) is the maximum hourly rate of vehicle that can cross a point or a road section according to road, traffic and control conditions without the degree of congestion falling below a preselected level as defined by the level of service.

Therefore, each road infrastructure has one of five traffic rates of service (the F level is not used because unstable). The chart below indicates the approximate rate of traffic service volume associated with the level of service.

Road Design Standards

Capacity Analysis and P.C.U

Capacity Analysis

Under ideal conditions, the ideal capacity for uninterrupted flow are as follows:

a. For, 2-lane two way (total) = 2,800 pcu/hr.

b. For, multilane (per lane) = 2,000 pcu/hr.

Ideal conditions consist of the following for two-lane roads:

a. Design speed greater than or equal to 100 km/hr.

b. Lane widths greater than or equal to 3.65m (12')

c. Clear shoulders wider than or equal to 1.83m (6 ')

d. No "No passing zones" on the highway.

e. All passenger cars in the traffic stream

f. A 50 / 50 directional split of traffic.

g. No impediments to through traffic due to traffic control or turning vehicles.

h. Level terrain.

When one or more of these conditions are not met, the actual capacity will be reduced. The effects of each are discussed in the Highway Capacity Manual which gives adjustment factors to be applied to the ideal capacity to determine the design capacity to be used for the design conditions.

Passenger Car Unit (P.C.U.)

Different types of vehicles in a traffic stream have different characteristics like width, length and height and sometimes they produce inconvenience for other vehicles, so for expressing highway capacity, a unit is used called passenger car unit or P.C.U.

Table G4: P.C.U. for Capacity Analysis

Type of Vehicle	Equivalent Value in p.c.u's			
	Rural	Urban	Roundabout Design	Traffic Signal Design
Motorcycle	1.0	0.75	0.75	0.33
Passenger Cars	1.0	1.0	1.0	1.0
Light Van	2.0	2.0	2.0	2.0
Medium Lorries	2.5	2.5	2.8	1.75
Heavy Lorries	3.0	3.0	2.8	2.25
Buses	3.0	3.0	2.8	2.25

Table G5: P.C.U. for Signalised Design with grade

Type of Vehicle	Grade %				
	-4%	-2%	0%	2%	4%
Motorcycle	0.3	0.4	0.5	0.6	0.7
Passenger Cars	0.8	0.9	1.0	1.2	1.4
SU	1.0	1.2	1.5	2.0	3.0
WB-50	1.2	1.5	2.0	3.0	6.0
All Vehicles*	0.9	1.0	1.0	1.4	1.7

* If vehicle composition is unknown, these values may be used as approximation.

Road Design Standards

Design Vehicles

P Design
is used at intersection where absolute minimum turns are stipulated such as:

- at local street intersections
- intersections of two minor roads with low volumes
- major roads where turns are made only occasionally

SU Design
is the recommended minimum design for all roads. For major highways with important turning movements which involves high percentage of trucks, larger radius and speed change lanes should be considered.

WB-15 Design
should be used where truck combinations will make turning movements repeatedly.

Table G6: Vehicle Dimension under current Malaysia's Legislation

Vehicle Type	Max. Allowable Overall Length	Max. Allowable Overall Width	Max. Allowable Overall Height
i. Rigid Vehicle ii. Articulated Vehicle iii. Semi-Trailer iv. Trailer v. Truck Trailer	16 m or 25 m if with special approval	2.5 m	4.2 m

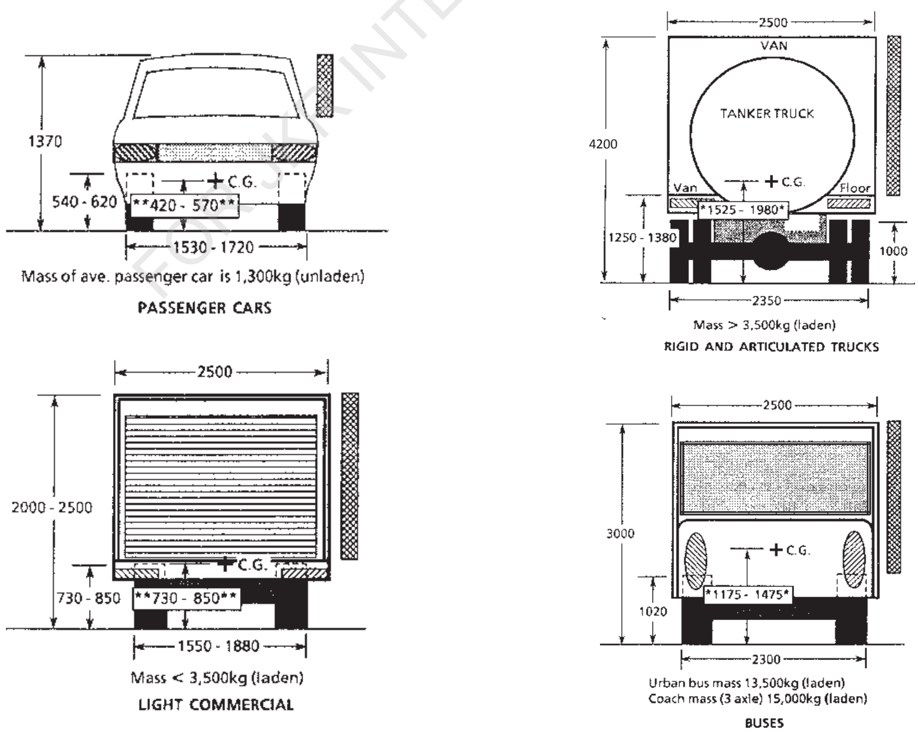
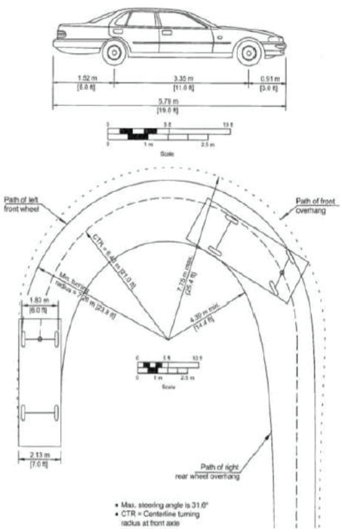


Figure G5: Properties of Some Design Vehicles

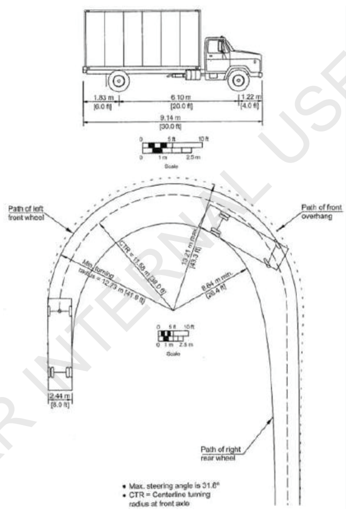
Road Design Standards

Turning Characteristics of Design Vehicles

P - Passenger Car



SU - Single Unit Truck



WB-15 - Truck Combination

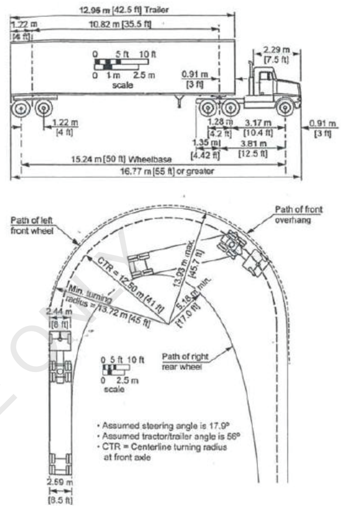


Figure G6: Turning Characteristic of Various Design Vehicles

Table G7: Dimension of Design Vehicles

Design Vehicle		Dimension in metre						Turning Radius
Type	Symbol	Wheel Base	Overall		Overall Length	Overall Width	Height	
			Front	Rear				
Passenger car	P	3.35	0.91	1.52	5.79	2.13	1.30	7.26
Single Unit Truck	SU	6.10	1.22	1.83	9.12	2.44	3.4-4.1	12.73
Truck Combination	WB-15	WB1: 4.45 WB2: 10.79	0.91	0.60	16.77	2.29	4.10	13.72

Road Design Standards

Cross-Sectional Elements

The art of road design is the geometric combination of elements which establish the road layout to ensure an appropriate final road design. Important geometric requirements also apply to the carriageway cross-section. The following passages described about most of the cross-sectional elements of a road:

Pavement Surface Type

Selection of pavement surface type is determined by

- Volume/composition of traffic,
- Soil characteristic,
- Weather,
- Availability of materials,
- Initial cost,
- Overall annual maintenance and service life cost.

Table G8 : Pavement Surface Type

Design Standard	Possible Pavement Surface Type
R6/U6	Asphaltic concrete/Concrete/Specialty Mix
R5/U5	Asphaltic concrete/Concrete/Specialty Mix
R4/U4	Asphaltic concrete/Specialty Mix
R3/U3	Asphaltic concrete /Concrete/Specialty Mix
R2/U2	Surface Treatment/Semi-grout/Asphaltic concrete
R1/U1	Gravel/Surface Treatment

Cross Slope

- A reasonably steep lateral slope is desirable to minimise water ponding on pavements.
- A steep cross slope is also a desirable on curbed pavements to confine water flow to a narrow width of pavement adjacent to the curb.
- Steep cross slope is undesirable on tangents because of the tendency of vehicle to drift toward.

Lane width

- Width subject to the selected road design standard
- Depend on speed of travel, size of vehicles, steerability of vehicles and conditions of adjacent lane
- Road capacity depends on no of traffic lane and the width
- Lane width may be determined by ADT volume of commercial vehicles and requirement of over taking and passing

Shoulder

- Defined as portion of the roadway continuous with the traveled way for accommodation of stopped vehicles, for emergency use and for lateral support to the pavement.
- Width subject to the selected road design standard with width range of 1.5m to 3.0m.
- Basically, there are two types of shoulders: paved and unpaved shoulder.
- Paved shoulder: min 1.5m for R3 to min 2.5m for R6 standard.

Road Design Standards

Cross-Sectional Elements

Marginal strip

- Width subject to the selected road design standard .
- This is a narrow pavement strip at the left and right single carriageway road and both sides for divided roads.
- It is a part of shoulder width with edge line marking .

Kerb

- Usually constructed from 30MPa concrete but may also be constructed from asphalt.
- **Barrier**: kerb face gradient 4v:1h.
- **Semi-barrier**: 1v:1h (top half); vertical kerb face (lower half).
- **Semi-mountable**: vertical kerb face (lower third); 0.6v:1h for upper region.
- **Mountable**: kerb slope 1v:12h (also called layback or roll-over kerb).
- Channel kerbs should be considered for roads built on high embankment and for roads with wide roadway.

Table G9: Some Basic Minimum Width

Feature	Minimum Width
Pedestrian Path	1.0m (1 way); 1.5m (2 way)
Dist. from pedestrian path to kerb	1.0m
Vehicle clearance	0.5m (slow); 1.0m (fast)
Car width / Truck width	2.0m / 2.5m
Car park lane	2.5m
Services	2.75m
Normal lane	3.5m*
Cars passing cars / trucks	4.0m / 4.8m

Median

- Width subject to the selected road design standard.
- Wider median is usually required for installation of U-turn facilities.
- May be virtually separated by chevron markings (ghost median) or physically separated by unpaved earth strip, raised kerb, guardrail, wire roped or concrete barrier.
- Raised kerb median is used as pedestrian refuge while crossing the road.

Cut and Fill Slopes

- The slope, width and height of benches depend on the results of the soil investigation conducted and analysed.
- Generally for cut section the slope is between 1:1 to 1:1.5 for normal earth slopes. For cutting in rock the slope is between 1:6 to 1:4.
- Berms are limited to a maximum of 6 nos. only.
- For embankment, the slope is generally between 1:1.5 to 1:2.
- Benches on fill slopes shall generally be of width 1.5m and of slope 1:25 away from the carriageway.

All slopes and benches shall be close turfed.

Pedestrian Crossing

- This facility is an integral part of urban roads and along rural roads with high pedestrian traffic especially points of community development.
- Justification may depend on vehicle - pedestrian hazard which Is governed by the volumes of pedestrian and vehicular traffic, their relative timing and speed of the vehicular traffic.
- Minimum width 1.5m; desirable width 2.0m.
- Must be provided with all weather surfacing and must be free from obstructions.
- Should incorporate facilities for the handicapped such as kerb ramps, textured guide surfacing and audible signalised crossing.

Road Design Standards

Roadsize Clear Zone

Roadside Clear Zone is defined as the total roadside border area, starting at the edge of the travelled way, available for safe use by errant vehicles. The primary function of clear zone is to allow space and time for the driver to retain control of his vehicle and avoid or reduce the consequences of collision with roadside objects.

The minimum width of clear zone depends on the Average Daily Traffic (ADT), operating speed and the geometric of the roads. The charts are used to determine the appropriate width of clear zone including that for curves.

Figure G7: Clear Zone Width on Straights

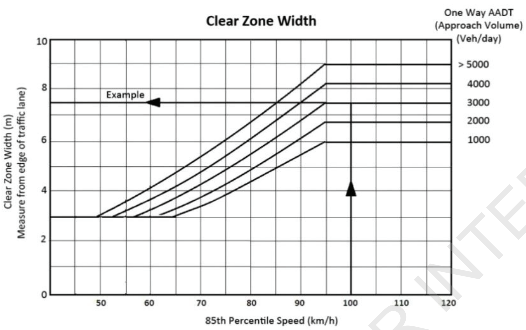


Figure G7: Clear Zone Width on Straights

Example:
One way AADT = 3000 (veh/day)
Operating Speed = 90km/h
Clear Zone width = 6.8m

Source: Austroads

Figure G8: Clear Zone Width on Curve (CZWC) CZWC = Clear Zone Width on Straights x Fc

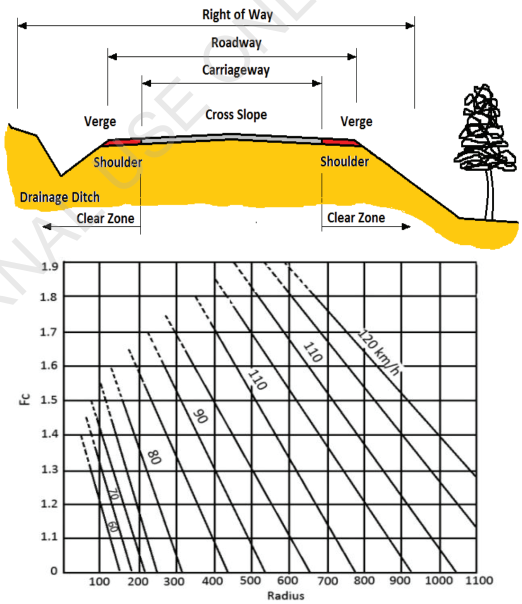


Figure G8: Clear Zone Width on Curve (CZWC)
CZWC = Clear Zone Width on Straights x Fc

Example:
Radius = 335m; Operating speed = 90km/h
therefore, Fc = 1.45
Clear Zone width = 6.8 x 1.45 = 9.86m

Road Design Standards

Selection of Design Standard for Roads

The selection of the required design standard should begin with the assessment of the function of the proposed road and the area it traverses. This should generally be done in conjunction with the highway planning process. If there is an overlapping of function, the ultimate function of the road shall be used for the selection criteria.

The projected ADT at the end of the design life (20 years) is calculated and the required design standard can be obtained from the table below. From the capacity analysis the required number of lanes can then be calculated.

Table G10: Road Design Standard based on Projected ADT

AREA	Road Category	Project ADT					
		All Traffic Volume	>10,001	3,001 to 10,000	1,001 to 3,000	151 to 1,000	< 150
RURAL	Expressway	R6	-	-	-	-	-
	Highway	R5	-	-	-	-	-
	Primary Road	-	R5	R4	-	-	-
	Secondary Road	-	-	R4	R3	-	-
	Minor Road	-	-	-	-	R2	R1
URBAN	Expressway	U6	-	-	-	-	-
	Arterials	-	U5	U4	-	-	-
	Collectors	-	U5	U4	U3	-	-
	Local Street	-	-	U4	U3	U2	U1

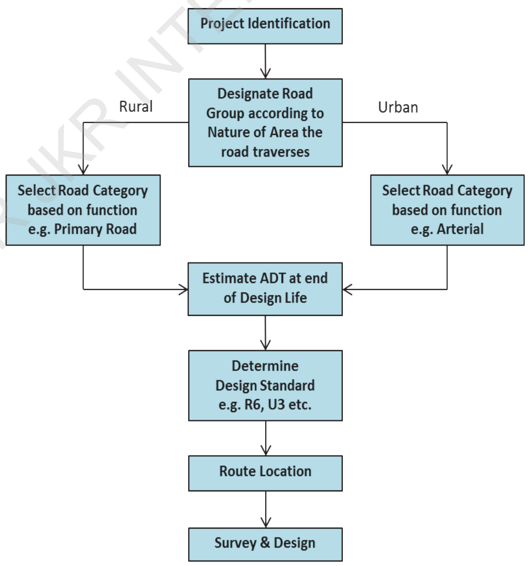


Figure G9: Flow Chart of the Selection of Design Standard for roads

Note:
Traffic volume is the projected ADT at the end of the design life (20 years after completion of the road).

Road Design Standards

Design Speed for Roads in Rural and Urban Areas

Table G11: Design Speed (Rural)

Design Standard	Design Speed (km/h)		
	Terrain		
	Flat	Rolling	Mountainous
R6	120	100	80
R5	100	80	60
R4	90	70	60
R3	70	60	50
R2	60	50	40
R1	40	30	20

Table G12: Design Speed (Urban)

Design Standard	Design Speed (km/h)		
	Area Type		
	I	II	III
U6	100	80	60
U5	80	60	50
U4	70	60	50
U3	60	50	40
U2	50	40	30
U1	40	30	20

Design Speed

Design speed is the maximum safe speed that can be maintained over a specified section of the road when conditions are so favorable that the design features of the road governs. The assumed design speed should be a logical one with respect to the topography, the adjacent land use and the type of road. Every effort should be made to use as high a design speed as practicable while maintaining the desired degree of safety, mobility and efficiency.

Type of Terrain

Flat - topographical condition generally with long sight distance and the natural ground cross slope less than 3%.

Rolling - topographical condition with natural slopes consistently rise and fall with occasional steep slopes. The natural ground cross slopes are generally between 3% - 25%.

Mountainous - topographical conditions where longitudinal and transverse changes in the elevation of the ground are abrupt. The natural ground cross slopes are generally above 25%.

Type of Development Area

Type I - relatively free in road location with very little problems as regards to land acquisition, affected buildings or other socially sensitive areas.

Type II - Intermediate between I and II.

Type III - Very restrictive in road location with problems as regard acquisition, affected buildings or other socially sensitive areas.

Road Design Standards

Summary on Geometric Design Criteria for Roads in Rural Area

Table G13

DESIGN CONTROL & CRITERIA	1	Design Standard		**R6**			**R5**			**R4**			**R3**			**R2**			**R1**		
	2	Access Control	-	Full			Partial			Partial/NIL			Partial/NIL			NIL			NIL		
	3	Terrain	-	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M
	4	Design Speed	km/h	120	100	80	100	80	60	90	70	60	70	60	50	60	50	40	40	30	20
CROSS SECTION ELEMENTS	5	Lane width	m	3.65			3.50			3.50			3.25			3.00			(5.00)a		
	6	Usable Shoulder Width	m	3.0	3.0	2.5	3.0	3.0	2.5	3.0	3.0	2.0	2.5	2.5	2.0	2.0	2.0	1.5	1.5	1.5	1.5
	7	Median Width (minimum)	m	4.0	4.0	4.0	4.0	3.0	2.0	3.0	2.0	1.5	N/A			N/A			N/A		
	8	Median Width (desirable)	m	10.0	10.0	10.0	6.0	5.0	4.0	5.0	4.0	3.0	N/A			N/A			N/A		
	9	Marginal Strip Width	m	0.50			0.50			0.25			0.25			0.25			0.00		
	10	Minimum reserve width	m	60			60 (50)b			40 (30) b			25			20			20		
	11	Stopping Sight Distance	m	250	185	130	185	130	85	160	105	85	105	85	65	85	65	50	50	35	20
	12	Passing Sight Distance	m	775	670	540	670	540	410	615	485	410	485	410	345	410	345	270	270	200	200
ELEMENTS OF DESIGN	13	Minimum Radius (at Max SE 10%)	m	595	360	210	360	210	115	275	160	115	160	115	75	115	75	45	45	25	10
	14	Minimum Length of Spiral	m	95	80	70	80	70	60	76	65	60	65	60	55	60	55	51	51	48	38
	15	Maximum Superelevation	Ratio	0.10																	
	16	Minimum Radius (at Max SE 8%)	m	665	396	230	396	230	125	305	175	125	175	125	80	125	80	50	50	30	10
	17	Minimum Length of Spiral	m	76	65	57	65	57	48	57	52	48	52	48	44	48	44	41	41	38	32
	18	Maximum Superelevation	Ratio	0.08 (sub-urban)																	
	19	Maximum Grade (desirable)	%	2	3	4	3	4	5	4	5	6	5	6	7	6	7	8	7	8	9
	20	Maximum Grade	%	3	4	6	3	5	8	6	8	10	7	8	10	7	10	15	7	11	17
	21	Crest Vertical Curve (K)	-	144	78	39	78	39	17	59	26	17	26	17	10	17	10	10	10	5	3
	22	Sag Vertical Curve (K)	-	63	45	30	45	30	18	38	23	18	23	18	13	23	13	9	9	6	3

•All values shown above are minimum/maximum values . All effort should be made to achieve as high a value as possible

•Abbreviation:

F - Flat
M - Mountainous
R - Rolling
N/A = Not Applicable
( ) a - Total Width of Pavement
( ) b - Reserve Width Depends in Road Category

Road Design Standards

Design Speed for Roads in Rural and Urban Areas

Table G14

DESIGN CONTROL & CRITERIA	1	Design Standard		U6			U5			U4			U3			U2			U1		
	2	Access Control	-	Full			Partial			Partial/NIL			Partial/NIL			NIL			NIL		
	3	Area Type	-	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M
	4	Design Speed	km/h	100	80	60	80	60	50	70	60	50	60	50	40	50	40	30	40	30	20
CROSS SECTION ELEMENTS	5	Lane width	m	3.65			3.50			3.50			3.25			3.00			(5.00)a		
	6	Usable Shoulder Width	m	3.0	3.0	2.5	3.0	3.0	2.5	3.0	2.5	2.0	2.5	2.0	1.5	2.0	1.5	1.5	1.5	1.5	1.5
	7	Median Width (minimum)	m	4.0	3.5	2.0	3.0	2.5	2.0	2.5	2.0	1.5	2.0	1.5	1.5	N/A			N/A		
	8	Median Width (desirable)	m	9.0	6.0	4.0	6.5	4.0	3.0	5.0	3.0	2.0	4.0	2.0	2.0	N/A			N/A		
	9	Marginal Strip Width	m	0.50			0.50			0.25			0.25			0.25			0.00		
	10	Minimum reserve width	m	65			65			40			40			30			25		
	11	Stopping Sight Distance	m	185	130	85	130	85	65	105	85	65	85	65	50	65	50	35	50	35	20
	12	Passing Sight Distance	m	670	540	410	540	410	345	485	410	345	410	345	270	345	270	200	270	200	200
ELEMENTS OF DESIGN	13	Minimum Radius (at Max SE 6%)	m	435	250	135	250	135	90	195	135	90	135	90	55	90	55	30	55	30	15
	14	Minimum Length of Spiral	m	48	43	36	43	36	33	39	36	33	36	33	31	33	31	29	31	29	25
	15	Maximum Superelevation	Ratio	0.06																	
	16	Maximum Grade (desirable)	%	3	4	5	4	5	6	5	6	7	6	7	8	7	8	9	7	8	9
	17	Maximum Grade	%	3	5	7	6	8	11	8	10	12	9	11	13	7	11	16	7	11	17
	18	Crest Vertical Curve (K)	-	78	39	17	39	17	10	26	17	10	17	10	10	10	10	5	10	5	3
	19	Sag Vertical Curve (K)	-	45	30	18	30	18	13	23	18	13	18	13	9	13	9	6	9	6	3

•All values shown above are minimum/maximum values . All effort should be made to achieve as high a value as possible

•Abbreviation:

N/A = Not Applicable

( ) a - Total Width of Pavement

( ) b - Reserve Width Depends in Road Category

Road Design Standards

Horizontal Alignment

Horizontal Curves

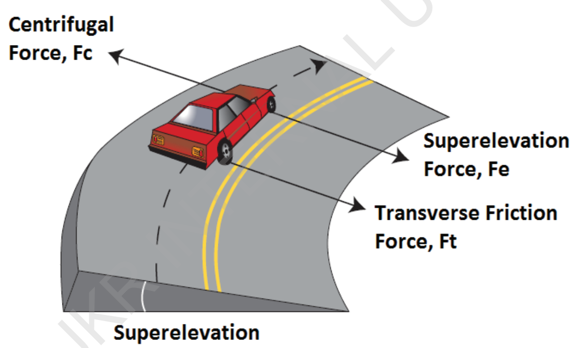
In the design of horizontal curves, it is necessary to establish the proper relationship between the design speed and curvature and also their joint relations with superelevation and side friction. From research and experience, limiting values have been established for the superelevation (e), and the coefficient of friction (f).

Superelevation Rates

The maximum rates of superelevation usable are controlled by several factors such as climatic conditions, terrain conditions and frequency of very slow moving vehicles that would be subjected to uncertain operation. While it is acknowledged that a range of values should be used, for practical purposes in establishing the design criteria for horizontal alignment, a maximum superelevation rate of 10% is used for, roads in rural areas and 6% for roads in urban areas.

For areas where climatic condition causes often slippery road condition and operating at slow speed the superelevation should not exceed 10%

Curve - System of Forces



Minimum Radius

The minimum radius is a limiting value of curvature for a given speed and is determined from the maximum rate of superelevation and the maximum allowable side friction factor. The minimum safe radius (Rmin) can be calculated from the standard curve formula:

$$R_{min} = \frac{V^2}{127\,(e + f)}$$

where ;

Rmin = minimum radius of circular curve(m)

V = design speed (km/h)

e = maximum superelevation rate

f = maximum allowable side friction factor

Minimum radii values may be calculated using the equation but with low coefficients of the transverse friction in order to:

- take into account driving conditions that are difficult but not exceptional;
- avoid substantial increases in curve braking distances;
- give vehicle occupants with an acceptable level of comfort.

Transition (Spiral) Curves

To design a road with built in safety, the alignment should be such that a driver travelling at the design speed will not only find it possible to confine his vehicle to the occupied lane but will be encouraged to do so. Vehicles need to follow a transition path as it enters or leave a circular horizontal curve. Spiral transition curves or Euler spiral (sometimes known as clothoid) are used for this purpose. The degree of this curve varies from zero at the tangent end of the spiral to the degree of the circular arc at the circular curve end.

For pavement with more than 2 lanes and standard lane width of 3.6m, the superelevation runoff length should be as follows:

i. 3 lane pavements (1.5 lane rotated) - 1.25 times the length for 2-lane roads.
ii. 4 lane undivided pavements (2 lanes rotated) - 1.5 times the length for 2-lane roads.
iii. 6 lane undivided pavement (3 lanes rotated) - 2.0 times the length for 2-lane roads.

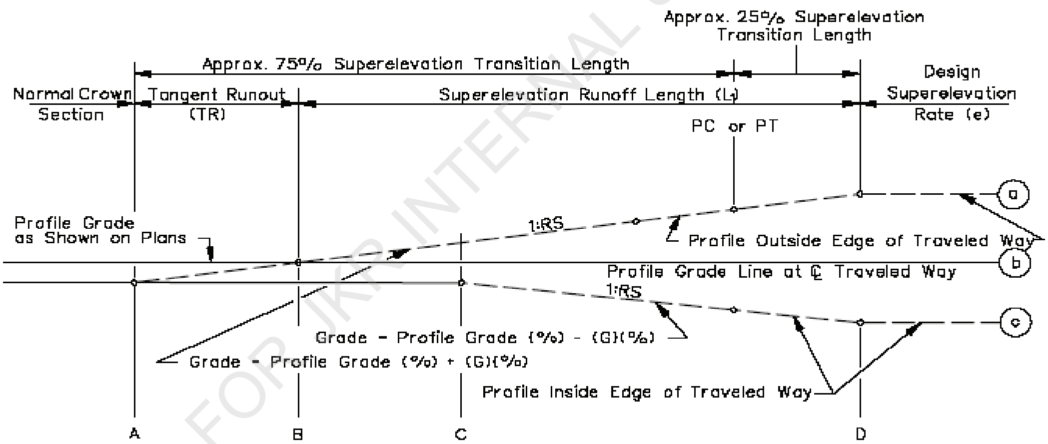


Figure 10: General Profile of Attaining Superelevation

Road Design Standards

Vertical Alignment

Vertical Curves

Vertical curves are used to create a gradual change between tangent grades. This should result in a design that is safe, comfortable in operation, pleasing in appearance and adequate for drainage. A parabolic curve with an equivalent vertical axis centred on the vertical point of intersection is commonly used.

The rate of change of grade to successive points on the curve is a constant amount for equal increments of horizontal distance, and equals the algebraic difference between the intersecting tangent grades divided by the length of curve or A/L in % per metre.

The reciprocal L/A is the horizontal distance in metre required to effect a 1% change in gradient and is a measure of curvature. This quantity (**L/A**), termed **k**, is used in determining the horizontal distance from the beginning of the vertical curve to the apex or low point of the curve. The k value is also useful in determining the minimum lengths of vertical curves for the various design speeds.

The lengths of vertical curves used should be as long as possible and above the minimum values for the design speeds where economically feasible.

Minimum lengths of crest vertical curves are determined by the sight distance requirements. Stopping sight distance is the main controlling factor for the safe operation at the chosen design speed.

The basic formulas for length of a parabolic vertical curve in terms of algebraic difference in grade and sight distance are as follows:

where S is less than L,

$$L = AS^2/404$$

where S is greater than L,

$$L = (2S - 404/A)$$

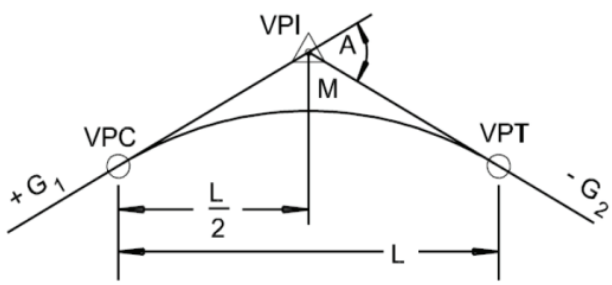
where

L = length of vertical curve (m)

S = sight distance (m)

A = algebraic difference in grades (%)

VPI	Vertical Point of Intersection
G1	Incoming Up Grade
G2	Outgoing Down Grade
A	Algebraic difference in grades
L	Length of Vertical Curve
M	Middle Ordinate



The minimum k values for crest and sag vertical curves are shown on the following page.

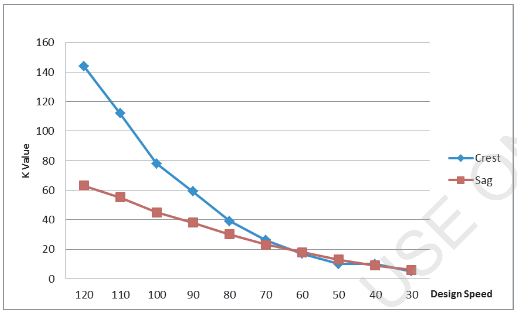
Road Design Standards

Vertical K - Values and Max / Min Grades

Table G15: K - Value for Crest and Sag

Design Speed	120	110	100	90	80	70	60	50	40	30
Min K value for Crest	144	112	78	59	39	26	17	10	10	5
Min K value for Sag	63	55	45	38	30	23	18	13	9	6

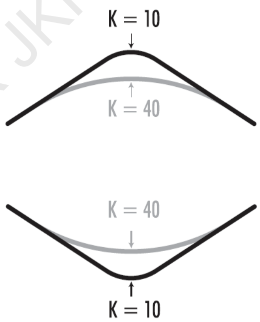
Figure G10 - K-Value for Crest and Sag



Maximum Grades

The vertical profile of road affects the performance of vehicles. The effect of grades on trucks which have weight power ratio of about 180kg/kW (300 lb/hp), is considered. The maximum grade controls in terms of design speed is summarised in the table below.

The total upgrade for any section of road should not exceed 3,000m unless the grade is less than 4%. The charts in the following page are the proposed maximum grades for rural and urban areas.



Examples of K Value for Crest and Sag

Minimum Grades

A desirable minimum grade or 0.5% should be used. A grade of 0.35% may be allowable where a high type pavement accurately crowned is used. On straight stretches traversing across wide areas of low lying swamp the use of even flatter grades may be allowable with prior approval. However, the design of storm water drainage outlet should be considered carefully at these locations so as to avoid flooding on the travelled way.

Where less than 0.5% longitudinal gradient is necessary, the superelevation runoff length used should be the minimum value permitted. This will minimise flat area along the carriageway where the cross falls are less than 1%. The use of open texture wearing course at this locations should be considered as this will help in preventing hydroplaning.

Road Design Standards

Maximum Grade for Roads in Rural Areas

Table G16a: Maximum Grade for R1 and R2

Type of Terrain / Area	Design Speed					
	30	40	50	60	70	80
Flat & Type I (%)	8	7	7	7	7	6
Rolling & Type II (%)	11	11	10	10	9	8
Mountainous & Type III (%)	16	15	14	13	12	10

Table G16b: Maximum Grade for R3 and R4

Type of Terrain / Area	Design Speed					
	50	60	70	80	90	100
Flat (%)	7	7	7	6	6	5
Rolling (%)	9	8	8	7	7	6
Mountainous (%)	10	10	10	9	9	8

Table G16c: Maximum Grade for R5

Type of Terrain / Area	Design Speed					
	60	70	80	90	100	110
Flat (%)	5	5	4	4	3	3
Rolling (%)	6	6	5	5	4	4
Mountainous (%)	8	7	7	6	6	5

Table G16d: Maximum Grade for R6

Type of Terrain / Area	Design Speed			
	80	90	100	110
Flat & Type I (%)	4	4	3	3
Rolling & Type II (%)	5	5	4	4
Mountainous & Type III (%)	6	6	6	5

Road Design Standards

Maximum Grade for Roads in Urban Areas

Table G17a: Maximum Grade for U1 and U2

Type of Terrain / Area	Design Speed					
	30	40	50	60	70	80
Flat & Type I (%)	8	7	7	7	7	6
Rolling & Type II (%)	11	11	10	10	9	8
Mountainous & Type III (%)	16	15	14	13	12	10

Table G17b: Maximum Grade for U3 and U4

Type of Terrain / Area	Design Speed				
	40	50	60	70	80
Type I (%)	9	9	9	8	7
Type II (%)	12	11	10	9	8
Type III (%)	13	12	12	11	10

Table G17c: Maximum Grade for U5

Type of Terrain / Area	Design Speed					
	50	60	70	80	90	100
Type I (%)	8	7	6	6	5	5
Type II (%)	9	8	7	7	6	6
Type III (%)	11	10	9	9	8	8

Table G17d: Maximum Grade for U6

Type of Terrain / Area	Design Speed			
	80	90	100	110
Flat & Type I (%)	4	4	3	3
Rolling & Type II (%)	5	5	4	4
Mountainous & Type III (%)	6	6	6	5

Critical Grade Length (CGL)

This is the maximum length of a designated upgrade upon which a loaded truck can operate without an unreasonable reduction in speed. To establish the design values for CGL, the following assumptions are made:

1. The weight-power ratio of a representative loaded truck is about 180kg/kW .
2. The average running speed as related to design speed is used to approximate the speed of vehicles beginning an uphill climb.
3. The common basis in the determination of the critical grade length is the reduction of speed of trucks below the average running speed. Studies show that the accident involvement rate increases significantly when truck speed reduction exceeds 15km/h. For example accident involvement rate is 2.4 times greater for 25km/h reduction than for a 15km/h reduction.

The length of any grade that causes the speed of representative truck (180kg/kW) entering the grade at 90km/h to reduce by various amount below the average of running speed is shown here. The 25km/h speed reduction curve should be used as the general design guide for determining the critical length of grade.

Where a particular section is made up of a combination of upgrade, the length of critical grade should take into consideration, the entire section of the combination.

Where the length of critical grade is exceeded and especially where grade exceeds 5% consideration should be given to providing an added uphill lane, for slowing moving vehicles, particularly where the volume is at or near capacity and the truck volume is high.

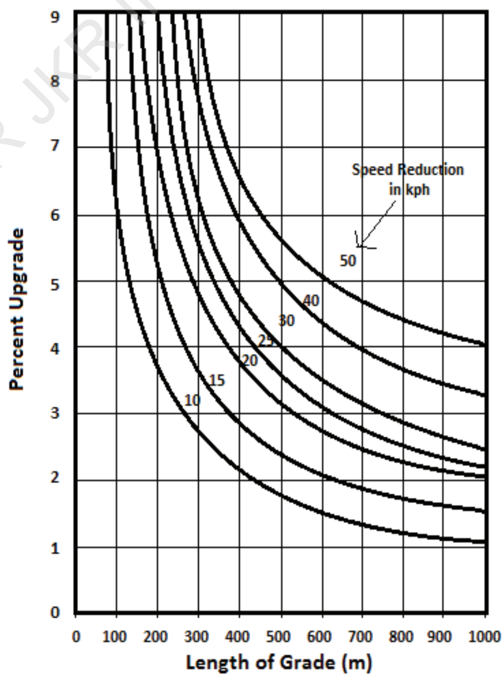


Figure G11: Critical Length of Grade (CGL) for Typical Heavy Trucks of 180kg/kW

Climbing Lane

Where the length of critical grade is exceeded especially when the grades is more than 5%, consideration should be given in providing an added uphill climbing lane for the slow moving vehicles, particularly where the traffic volume is at or near capacity and the truck volume is high. A climbing lane is an auxiliary lane introduced at the beginning of a sustained positive grade for the diversion of slow traffic.

In principle, climbing lane can be considered when the grade is too long that caused a decrease in truck speed to approximately 40km/h. Provision of climbing lane can also be considered under the following cases:

- Long grade over 8%
- Accident due to slow moving vehicles

Multilane roads more frequently have sufficient capacity to handle their traffic load, including the normal percentage or slow-moving vehicles without becoming congested. However where the volume is at or near capacity (1700 vehicle per hour per lane) and the truck volume is high (≥10% of total flow) so as to interfere with the normal flow of traffic then addition of climbing lanes should be considered.

Climbing Lanes for Two Lane Roads

The following conditions and criteria, which reflect economic consideration, should be satisfied to justify a climbing lane:

i. Upgrade peak traffic flow rate in excess of 200 vehicles per hour
ii. Upgrade truck peak flow rate in excess of 20 vehicles per hour
iii. One of the following conditions exist:
    - A 25km/h or greater speed reduction is expected for typical heavy truck.
    - Level of service E or F exist on the grade
    - A reduction of two or more levels of services is experienced approaching the start of the grade.

Where climbing lanes are provided, the following requirement are to be followed:

a. the climbing lanes should begin near the foot of the grade and should be proceeded by a tapered section of at least 50m long.
b. the width of the climbing lane should be the same as the main carriageway lane width and in any case should not be less than 3.25m.
c. the section of the road must be separated by a New Jersey Type Concrete Median with adequate signing and markings and the opposing lane widened also to 2 lanes to make it a four lane divided carriageway.
d. the climbing lane should end at least 60m beyond the crest and in particular should be at a point where the sight distance is sufficient to permit passing with safety. In addition, a corresponding taper length as in (a) of 100m should be provided.
e. the shoulder on the outer edge of the climbing lane should be as wide as the shoulder on the normal two lane section. Where conditions dictate otherwise, a useable shoulder width of 1:25m is acceptable.

Slow moving heavy vehicle along climbing lane tend to produce 'tracks' or severe rutting or shoving along the path of the vehicle.

Road Design Standards

Passing / Overtaking Lane

Overtaking Lane

An overtaking lane is an additional lane provided on a conventional two lane, two way road to increase overtaking opportunities and improve the overall traffic operation including safety. It may be used on flat or rolling terrain, or on sustained grades. When overtaking lanes are located on hills, they are known as 'climbing lanes'.

Overtaking lanes are generally warranted when the percentage of passing opportunity is less than 30% (the opportunity to overtake occurs less than 30% of the time). Where a sufficient number and length of safe passing section cannot be obtained in the design of horizontal and vertical alignment alone, an occasional section of three or four lanes may be introduced to provide more sections and length safe for passing. Such section are particularly advantageous in rolling terrain, especially where the alignment is winding or where the vertical profile includes critical lengths of grade.

Four lane sections, if introduced, should be sufficiently long to permit its effective usage and need not be divided. However, the use of a median is advantageous and should be considered on roads carrying 500 vehicles per hour or more.

The percentage passing opportunities depends upon:

1. the length of overtaking zone within the section of road expressed as the % overtaking zone and,
2. the availability of adequate gaps (exceeding 25 sec. in opposing traffic) in the opposing traffic stream.

Percentage of Passing Opportunities
= (% Overtaking zone) x (% Gaps)/100

where % Overtaking Zone (%OZ)
= (Length of overtaking zone /Length of road section) x100

General practice by PWD is to provide, where practicable, 1 km length of overtaking opportunity at every 3 km interval especially for single carriageway arterial roads. The locations for the overtaking lane can be based on locations where head-on collisions frequently occurred. Correctly located overtaking lanes are a cost effective means of improving the level of service on existing two lane two way roads. They can also be expected to reduce the accident rate by approximately 25% provided that all sight distance requirements are met.

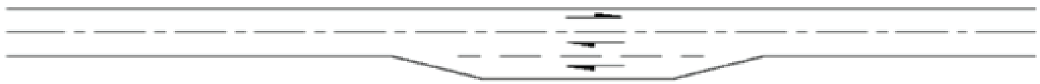
The designer should also take note that the provision of overtaking lane usually would increase the percentile speed of vehicle traveling along the road and may increase the accident risk among local commuters and pedestrians. Hence, overtaking lanes should not be located at built-up or kampong areas as this would reduce safety. Provision of overtaking lane must also include local improvement to any substandard geometry of the road alignment.

Road Design Standards

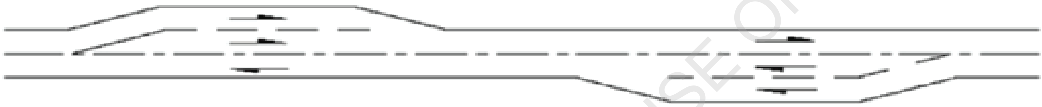
Type of Passing / Overtaking Lane

There are 5 possible types of overtaking lane layout. Overtaking lane is being provided every 3 km for each direction of travel. Designer should also take note of the termination end of the overtaking lane where the fast lane traffic is required to merge onto the left slow lane instead of otherwise.

a. Isolated Overtaking Lane

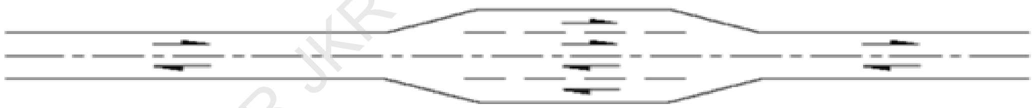


b. Separated Overtaking Lane

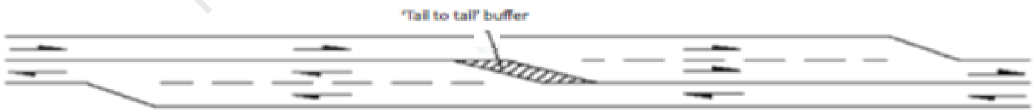


c. Continuous Overtaking Lane

d. Adjacent Overtaking Lane



e. Adjoined Overtaking Lane



Warrant Criteria for Motorcycle Lane on Non - Expressways

Table G18: Criteria to Warrant the Construction of Motorcycle Lane on NEML

Numerical Warrants		Type of Roads: Expressways	Type of Roads: Non-Expressways	Type of Roads: Section of Expressways and Non-Expressways
Type of Motorcycle Facilities		Exclusive motorcycle lane		
1.	Total Volume of Traffic	> 15,000 vehicle per day	> 15,000 vehicle per day along a 2- lane 2-way road OR > 10,000 vehicle per day per lane along a multi-lane road	• For Section with Expressway Road Conditions, Warrant for Expressways shall apply. OR • For Section with Non-Expressway Road Conditions, Warrant for Non Expressways shall apply. OR • For combination of Expressway and Non-Expressways along the road, the engineer's experience and engineering judgement is required to decide the most appropriate form of motorcycle facilities.
2.	Percentage of motorcycles	> 30% of main stream traffic	> 30% of main stream traffic	
3.	Total number of Motorcycle Accidents	> 5 accidents per km per year	> 5 accidents per km per year	
4.	Side Friction Scores	Not Applicable	< 30 friction scores (refer Appendix 2.0 for details)	
5.	Combination of 1,2,3 and/or 4	• Can be provided even if not fulfilling criteria 1, 2,3 or 4 if its absence would be detrimental to the safety of motorist/other road user. • Warrants if there is a high likelihood of warrants 1, 2,3 and/or 4 being met within 5 years of design life of the project.		

Road Design Standards

Sight Distance and Approach Stopping Sight Distances (ASD)

Sight Distances

Sight distance is the length of road ahead visible to drivers. The ability of a driver to see ahead is of utmost importance to the safe and efficient operation of a road. It must be provided as it allow drivers to control the speed of the vehicle to avoid striking an unexpected obstacle on the travelled way.

At frequent intervals and for substantial portion of length, 2 - lane undivided roads should provide sufficient sight distance to enable drivers to safely overtake other vehicles. Depending on the situation, there are various types of sight distance such as:

- Stopping sight distance
- Decision Sight Distance
- Entering sight distance
- Safe Intersection sight distance
- Passing sight distance

Table G19 : Minimum Stopping Sight Distance

Design Speed (kph)	Min. Stopping Sight Distance (m)
120	250
110	220
100	185
90	160
80	130
70	105
60	85
50	65
40	50
30	35

A driver (eye height - 1050 mm) needs to be able to see the surface (object height - 1330 mm) of the roadway at main conflict area, sufficiently far in advance to be able to stop if required before entering the conflict area and to be able to see the form of any channelization including lane and other pavement markings, and enter the intersection in the correct lane etc. The required sight distance is the minimum Stopping Sight Distance for various vehicle operating speeds.

Approach Stopping Sight Distance

Stopping sight distance is the length required to enable a vehicle travelling at or near the design speed to stop before reaching an object in its path. Therefore, minimum sight distance is the sum of two (2) distance:

a. From the moment driver sight an obstacle which require a stop to the instant brake applied
b. The distance required to stop the vehicle after brake had been applied

Table G20: Effect of Grade In Stopping Sight Distance

Design Speed (km/h)	Stopping Sight Distance (m)					
	Upgrade			Down Grade		
	3%	6%	9%	3%	6%	9%
30	32	35	35	31	30	29
40	50	50	53	45	44	43
50	66	70	74	61	59	58
60	87	92	97	80	77	75
70	110	116	124	100	97	93
80	136	144	154	123	118	114
90	164	174	187	148	141	136
100	194	207	223	174	167	160
110	227	243	262	203	194	186
120	263	281	304	234	223	214

Road Design Standards

Decision Sight Distances

Decision Sight Distance

Decision sight distance is the distance required for a driver to detect an unexpected object or otherwise difficult - perceive information source or hazard in a roadway environment that may be visually cluttered, recognize the hazard or its potential threat, select an appropriate speed and path, initiate and complete the required safety manoeuver safely and efficiently.

Because decision sight distance gives drivers additional margin for error and affords them sufficient length to manoeuver their vehicle at the same or reduced speed rather than to just stop, its values are substantially greater than stopping sight distance. Drivers need decision sight distance whenever there is a likelihood for error in either information reception, decision - making, or control actions. Drivers need decision sight distance whenever there is a likelihood for error in either information reception, decision - making, or control actions.

Entering Sight Distance (ESD)

The sight distance required for a vehicle or a pedestrian to observe a safe gap in uncontrolled traffic flow which to enter or cross the roadway including entry to roundabouts and at left turn slip roads, and for pedestrians at pedestrian crossings. It is also desirable to achieve this sight distance criteria at signalised intersections to ensure that they can operate safely when the signals may have "broken down".

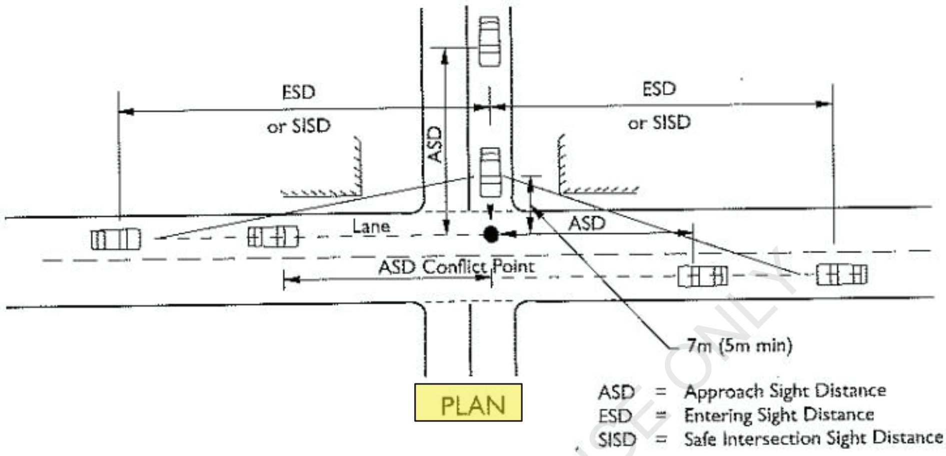
Safe Intersection Sight Distance (SISD)

In situation where ESD cannot fully be achieved, a "fail safe" criteria SISD may be applied. This criteria ensures that main road drivers (vehicle which have priority) will have sufficient sight distance to an entering vehicle, to enable them to avoid a collision if that side road driver enters the intersection with sufficient gap in the priority traffic stream.

The criteria provides sight distance equivalent to stopping distance for the expected 85th percentile operating speed plus the distance travelled in 3 seconds of travel time. The required sight distance is measured from the major road driver's eye height to the minor road vehicle waiting to enter the intersection.

Table G21: Decision Sight Distance

Design Speed (kph)	Decision Sight Distance For Avoidance Manoeuver (m)			
	A	B	C	D
50	70	155	145	195
60	95	195	170	235
70	115	235	200	275
80	140	280	230	315
90	170	325	275	360
100	200	370	315	400
110	235	420	330	430
120	265	470	360	470



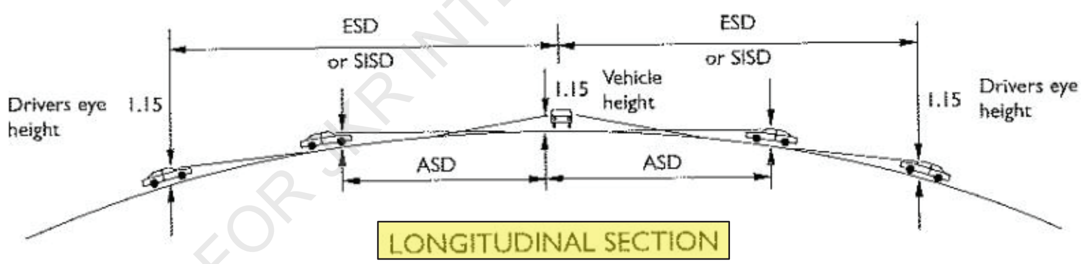


Figure G12 : Typical Plan And Longitudinal Sections Showing Various Sight Distances At Intersection

Passing Sight Distance

While passing is not an event that is a major factor in the design of four-lane highways, it is a critical component of two-lane highway design. The capacity of a two-lane roadway is greatly increased if a large percentage of the roadway's length can be used for passing. On the other hand, providing a sufficient passing sight distance over large portions of the roadway can be very expensive.

Simply put, the passing sight distance is the length of roadway that the driver of the passing vehicle must be able to see initially, in order to make a passing manoeuvre safely.

Our real goal is to provide most drivers with a sight distance that gives them a feeling of safety and that encourages them to pass slower vehicles.

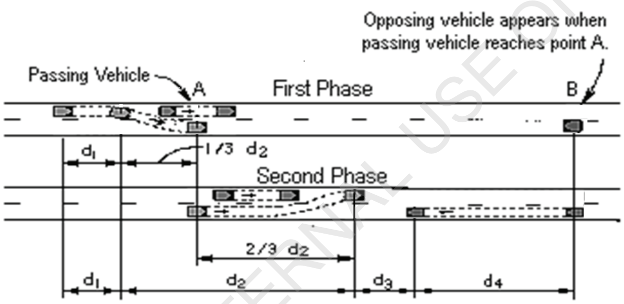


Figure G13 : Phases of Passing Sight Distance

The figure below shows the sequence involved in an overtaking manoeuvre which is divided into two phases. Some notes for the figure below:-

- D1 - Distance traversed during perception and reaction time and during the initial acceleration to the point of encroachment on the left lane.
- D2 - Distance travelled while the passing vehicle occupies the left lane.
- D3 - Distance between the passing vehicle at the end of its manoeuvre and the opposing vehicle.
- D4 - Distance traversed by an opposing vehicle for two- thirds of the time the passing vehicle occupies the left lane, or 2/3 of d2 above.

Table G22 : Passing Sight Distance

Design Speed (kph)	Min. Passing Sight Distance (m)
120	775
110	730
100	670
90	615
80	540
70	485
60	410
50	345
40	270
30	200

Road Design Standards

Driver's Reaction Time

Brake Reaction Time

The brake reaction time is the amount of time that elapses between the recognition of an object or hazard in the roadway and the application of the brakes. The length of the brake reaction time varies widely depending on drivers characteristics (attitude, level of fatigue, and experience), environmental conditions (clarity of the atmosphere and the time of day) and the properties of the hazard or object itself, such as size, colour and movement. An alert driver may react in less than 1 second, while other drivers may require up to 3.5 seconds.

For highway safety, the engineer must provide a continuous sight distance equal to or greater than the stopping sight distance. As an integral part of the stopping sight distance, a value for the brake reaction time must be assumed.

Based on extensive research, the brake reaction time normally used in design is 2.5 seconds. The distance travelled during the brake reaction time can be calculated by multiplying the vehicle's initial speed by the brake reaction time.

Both the brake reaction time and the braking distance are used in the calculation of the stopping sight distance.

Travel speed and brake reaction time influence the stopping distance of a vehicle. A car braking from 65km/h travel speed will still be travelling at 32km/h at the point where a vehicle braking from 60km/h has stopped.

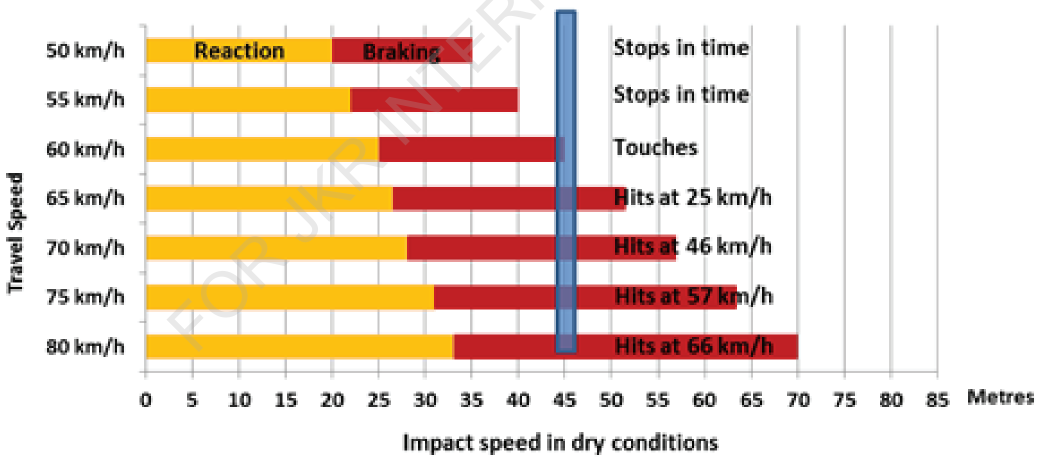


Figure G14: Relationship between travel speed, stopping distance and crash impact speed (Reaction time used is 1.5 secs)

90 km/h = 25 m/sec
60 km/h = 16.7 m/sec

Notes :
'A' - Most appropriate treatment
'B' - Appropriate treatment
'C' - Not the appropriate treatment
** - May incorporate speed control humps
*- Not at intersection. This include 'Pelican' and 'Puffin' type crossings

Table G23: Guide For Selecting Appropriate Type of Pedestrian Crossing Facilities

TYPE OF PEDESTRIAN FACILITY	**FUNCTIONAL CLASS / ROAD CATEGORY**				
	Expressway	Primary Arterial	Secondary Arterial	Collector Road	Local Road
	Expressway	Federal Road	State Road & Major Municipal Road	Municipal Road	Municipal Road
Uncontrolled Crossing	C	B	B**	B**	B**
School Children's Crossing	C	B	B**	A**	A**
Pedestrian (Zebra) Crossing	C	B	A**	A**	A**
Signalised Pedestrian Crossing*	C	A	B	B	C
Grade Separated Pedestrian Crossing	A	B	B	C	C

This general warrant is based on:
1. Pedestrian Volume
2. Traffic Volume
3. PV value

Road Type	General		Type of Crossing
	P	V	P = Pedestrian volume at peak hour
	PV		V = Vehicular volume at peak hour (1-way)
Others	<50	<1,000	Ordinary Unsignalised Level (Zebra) Crossing
	<50,000		
Others	50-100	1000-2000	Signalised Level (Pelican) Crossing
	50,000 - 200,000		
Others	>100	>2,000	Grade-separated crossing should be provided
	>200,000		
Dual 3-lane or more	any		Grade-separated crossing should be provided

ROAD SAFETY BARRIERS

Road Safety Barriers

Longitudinal Safety Barriers and NCHRP 350 Test Levels

Longitudinal Safety Barriers

Longitudinal traffic safety barriers are important safety features for our roads, to prevent out-of-control crashes and reduce the severity of run-off-road accidents. The function is to redirect any errant vehicle away from the embankment slopes or fixed objects and at the same time dissipating the energy of the collision.

These barriers must only be installed where it is clear that the accident severity would be less than that if an accident happened without it. However, prior to deciding on the use of the barrier, consideration should be given to the following actions (in their order of precedence):

1. Eliminate or remove the hazard;
2. Relocate the hazard;
3. Make the hazard breakaway or yield on impact;
4. Finally, if the above actions fail, then shield the hazard.

Categories of Barrier

1. Rigid barrier
2. Semi-rigid barrier (max. deflection 1.2m)
    - Group 1: Strong beam, weak post
    - Group 2: Strong beam, strong post
3. Flexible barrier
4. Crash cushions and other energy absorbing alternatives
5. Bridge railing and parapets
6. Kerbs (height below 150mm have little barrier effect)

Critical Barrier Parameters

1. Post spacing
2. Post strength
3. Rail height
4. Coefficient of friction, and to a lesser extent:
5. Rail tension, and
6. Soil stiffness

NCHRP Report 350 Test Level for Safety Barriers

NCHRP Report 350 is the US standard (AASHTO) for Road Restraint Systems. It is a guideline for testing both permanent and temporary road safety features. The objective of the testing is to determine the manner in which a road safety feature performs during a vehicle crash situation, for typical site and traffic conditions.

Table P1: Test Level Criteria

Test Level	Test Vehicles & Impact Angle	Test Speed
TL-1	a. 820kg Car (20°) b. 2000kg pickup truck (25°)	50km/h
TL-2	a. 820kg Car (20°) b. 2000kg pickup truck (25°)	70km/h
TL-3	a. 820kg Car (20°) b. 2000kg pickup truck (25°)	100km/h
TL-4	a. 820kg Car (20°) b. 2000kg pickup truck (25°) c. 8000kg single unit truck (15°)	100km/h 100km/h 80km/h
TL-5	a. 820kg Car (20°) b. 2000kg pickup truck (25°) c. 36000kg tractor/van trailer (15°)	100km/h 100km/h 80km/h
TL-6	a. 820kg Car (20°) b. 2000kg pickup truck (25°) c. 36000kg tractor/tank trailer (15°)	100km/h 100km/h 80km/h

The performance of barrier system is measured by their ability to:

1. Maintain structural integrity - errant vehicle must not break through, penetrate, vaulted over or wedge under the barrier;
2. Produce acceptable vehicle deceleration during impact - within human tolerance;
3. Redirect the vehicle within an acceptable post-impact trajectory - vehicle redirected with small exit angle and small rebound distance.

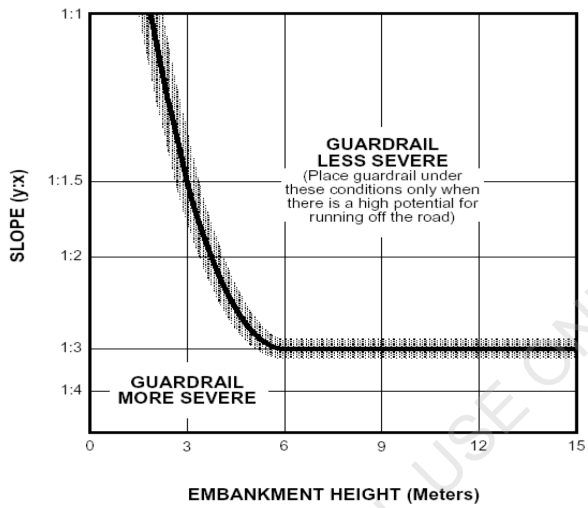


Figure P1: Warrant for Installation of Guardrail

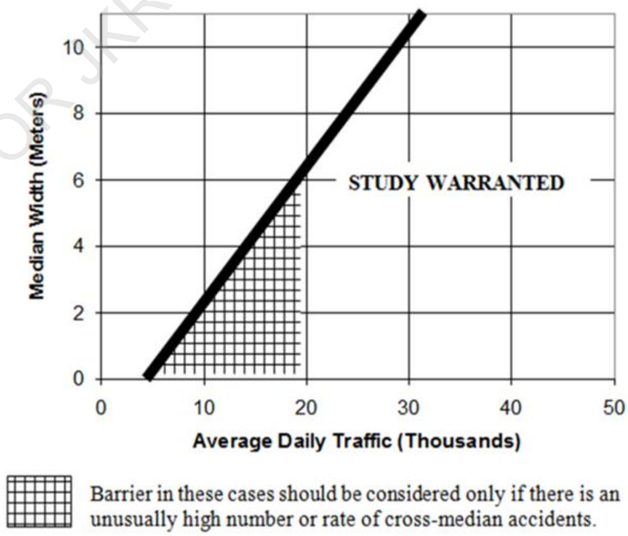


Figure P2: Median Barrier Study Warrant

Road Safety Barriers

Typical W-Beam Guardrail Barrier

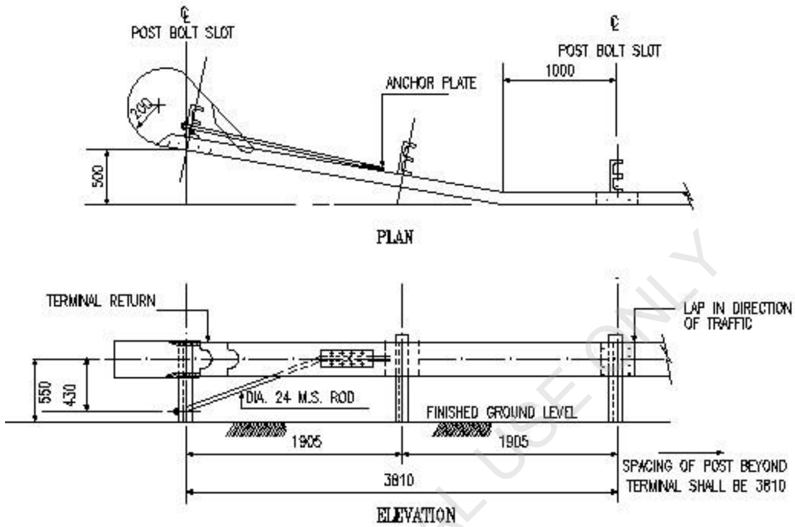
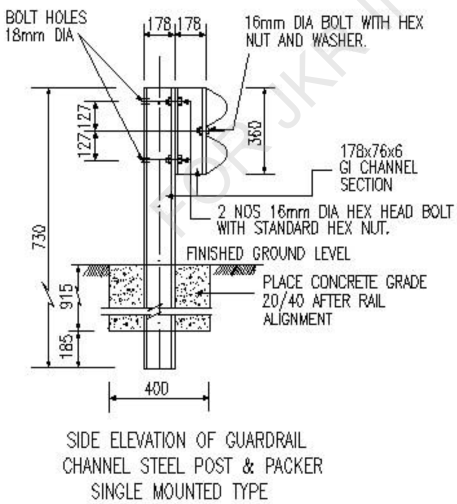


Figure P3: Typical Standard Drawing for W-Beam Guardrail



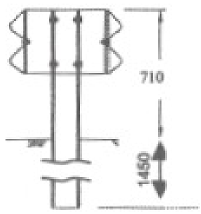
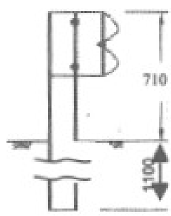
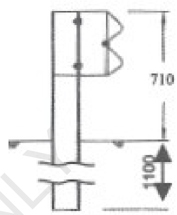
Properties	Value
Test Level	TL-3
Dynamic Deflection	1.2m (80 km/h); 1.6m (110km/h)
Post Spacing	2m (TL-3); 4m (TL-2)
Height	710mm
Barrier width (single sided)	380mm

Table P2: Technical Specification for Guardrail

Road Safety Barriers

Typical W-Beam Guardrail Barrier

Table P3: Types of W-Beam Guardrail

	On Median	On Shoulder	
			
	MB4S Blocked - Out 'W' Beam (Steel Post)	MB4S Blocked - Out 'W' Beam (Steel Post) 2.0 m spacing	MB4S Blocked - Out 'W' Beam (Steel Post) 4.0 m spacing
Maximum Deflection	0.6 m	1.0 m	0.6 m
Post Spacing	2.0 m	2.0 m	4.0 m
Post	C Section 150 x 76 x 6 mm	C Section 150 x 76 x 6 mm	C Section 150 x 76 x 6 mm
Beam	Double W - Beam	Single W - Beam	Single W - Beam
Off Set Brackets	Two C Sections 150 x 76 x 6 mm	Two C Sections 150 x 76 x 6 mm	Two C Sections 150 x 76 x 6 mm
Mountings	16 mm Ø Steel Bolts	16 mm Ø Steel Bolts	16 mm Ø Steel Bolts
Footing	None (Except at points of transition)	None (Except at points of transition)	None (Except at points of transition)

Road Safety Barriers

Typical Thrie Beam Guardrail

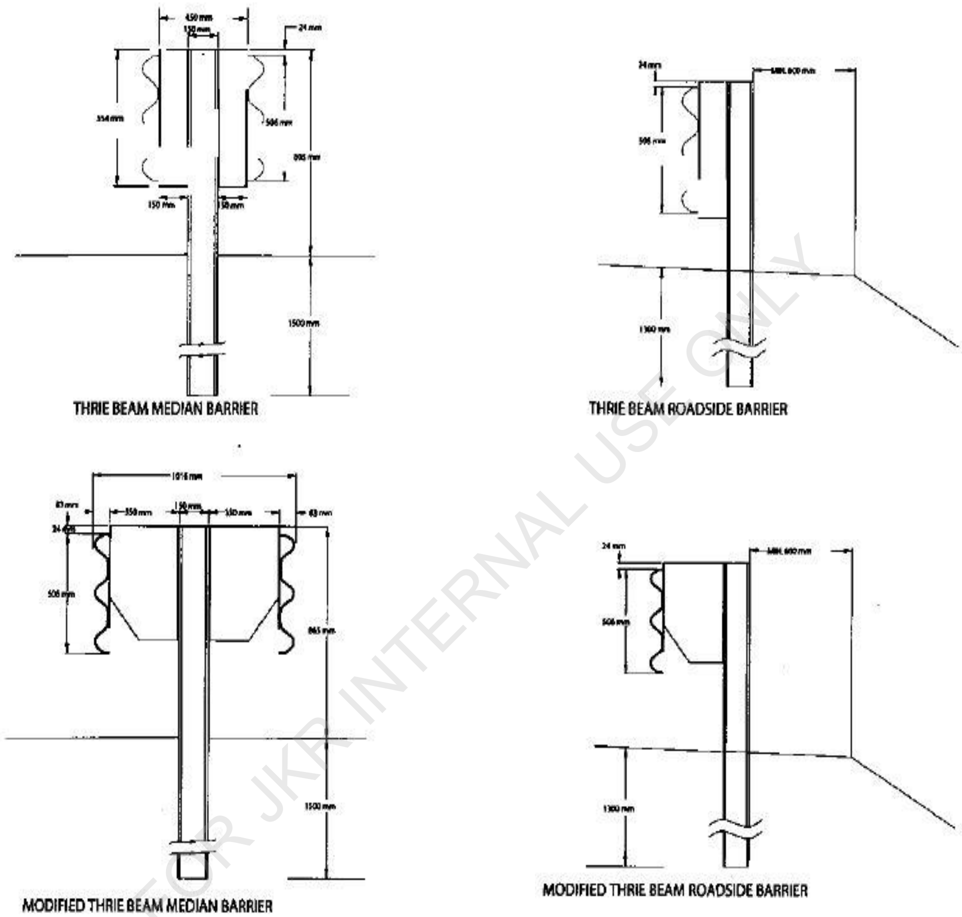


Figure P4: Typical Cross Sections for Thrie Beam Guardrail

Road Safety Barriers

Typical Wire Rope Safety Barrier

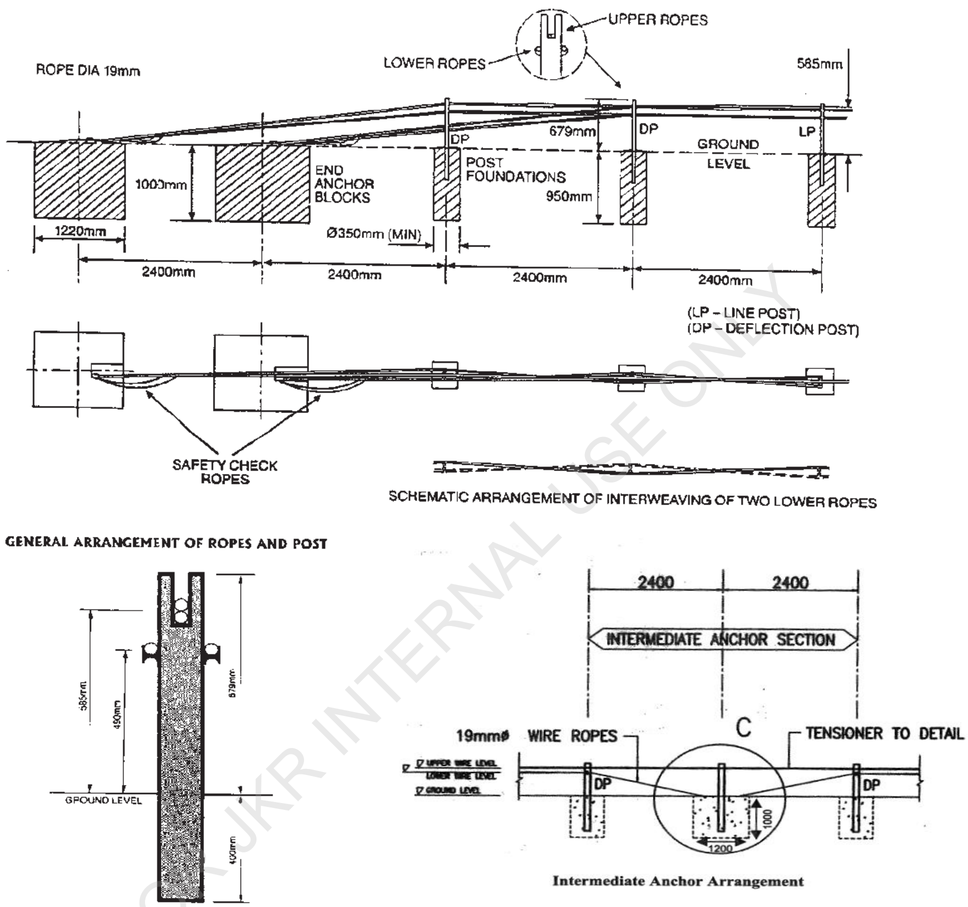


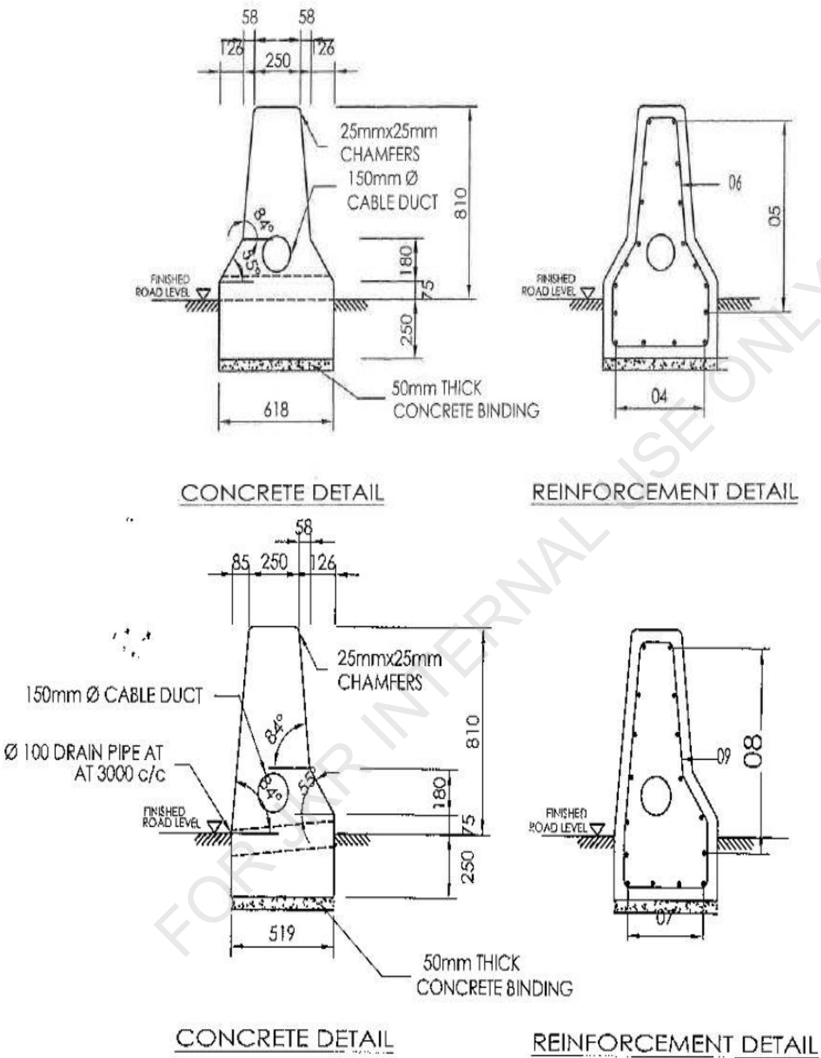
Figure P5: Typical Standard Drawing for Wire Rope Safety Barrier

Table P4: Technical Specification for WRSB

Properties	Value
Test Level	TL-3
Dynamic Deflection (>100m between anchors)	1.2m (80 km/h); 1.5m (110km/h)
Post Spacing	2.4m
Height (wire)	585mm ± 20mm
Barrier width (single sided)	80mm

Road Safety Barriers

New Jersey Barrier 810 mm (Reinforced)



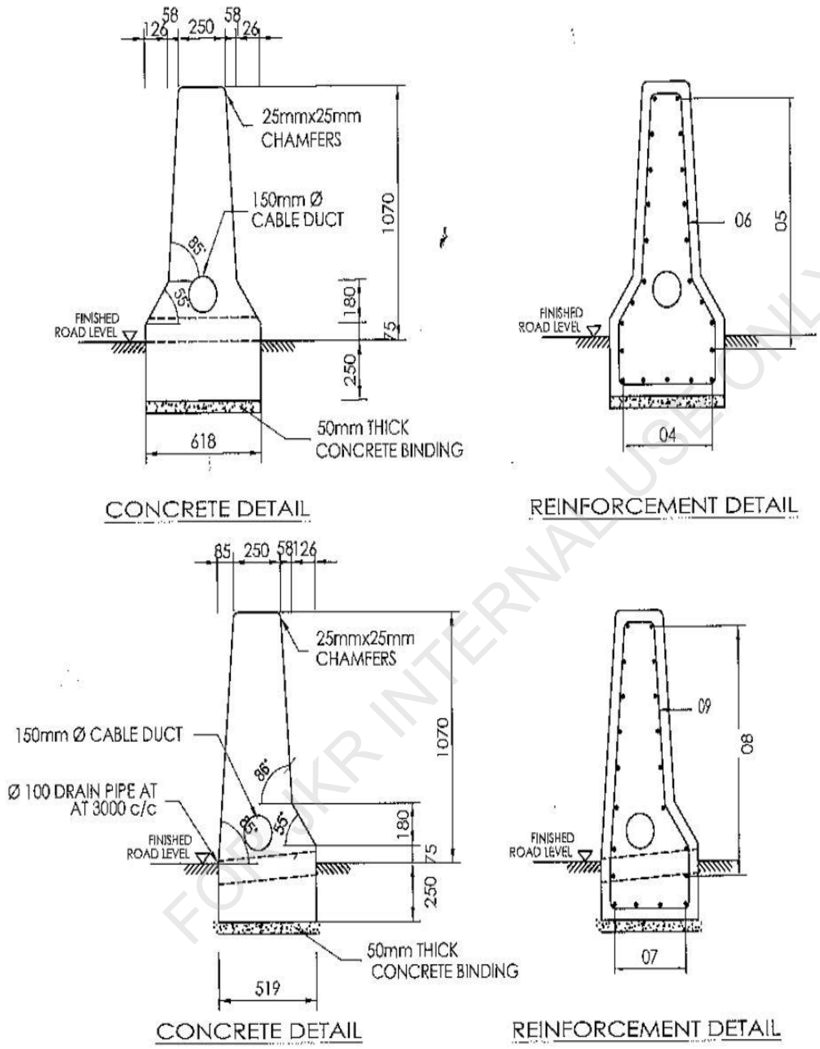
Barrier at median of road

Barrier at road side

Figure P6: Typical Cross Sections for Reinforced Concrete Barrier (810mm)

Road Safety Barriers

New Jersey Barrier 1070 mm (Reinforced)



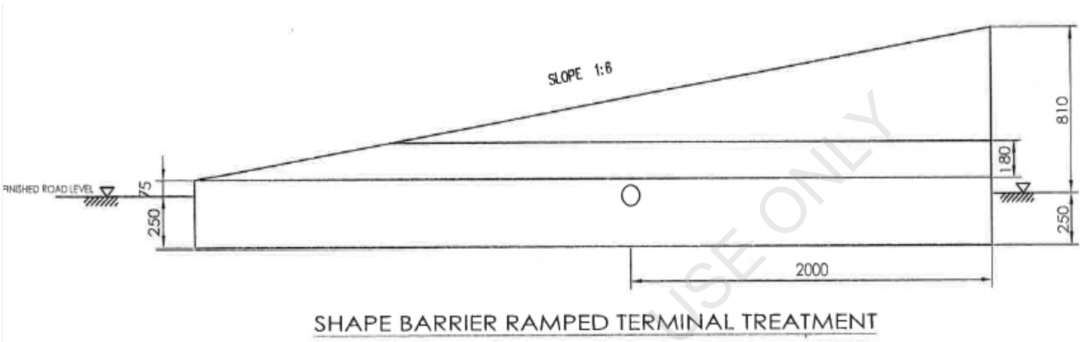
Barrier at median of road

Barrier at road side

Figure P7: Typical Cross Sections for Reinforced Concrete Barrier (1070mm)

Road Safety Barriers

New Jersey Barrier Ramped Terminal Treatment (810 mm & 1070 mm)



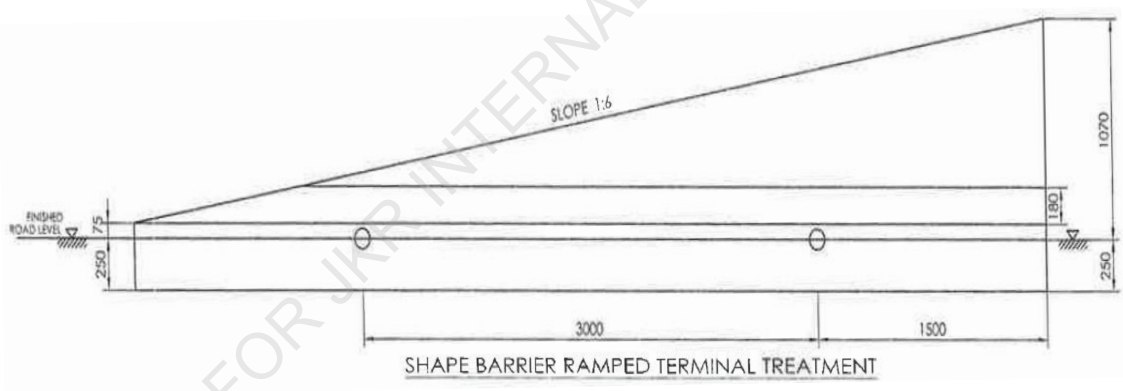


Figure P8: Reinforced Concrete Barrier Terminal Treatment

Road Safety Barriers

Treatment Of Guardrail At Bridge Parapet

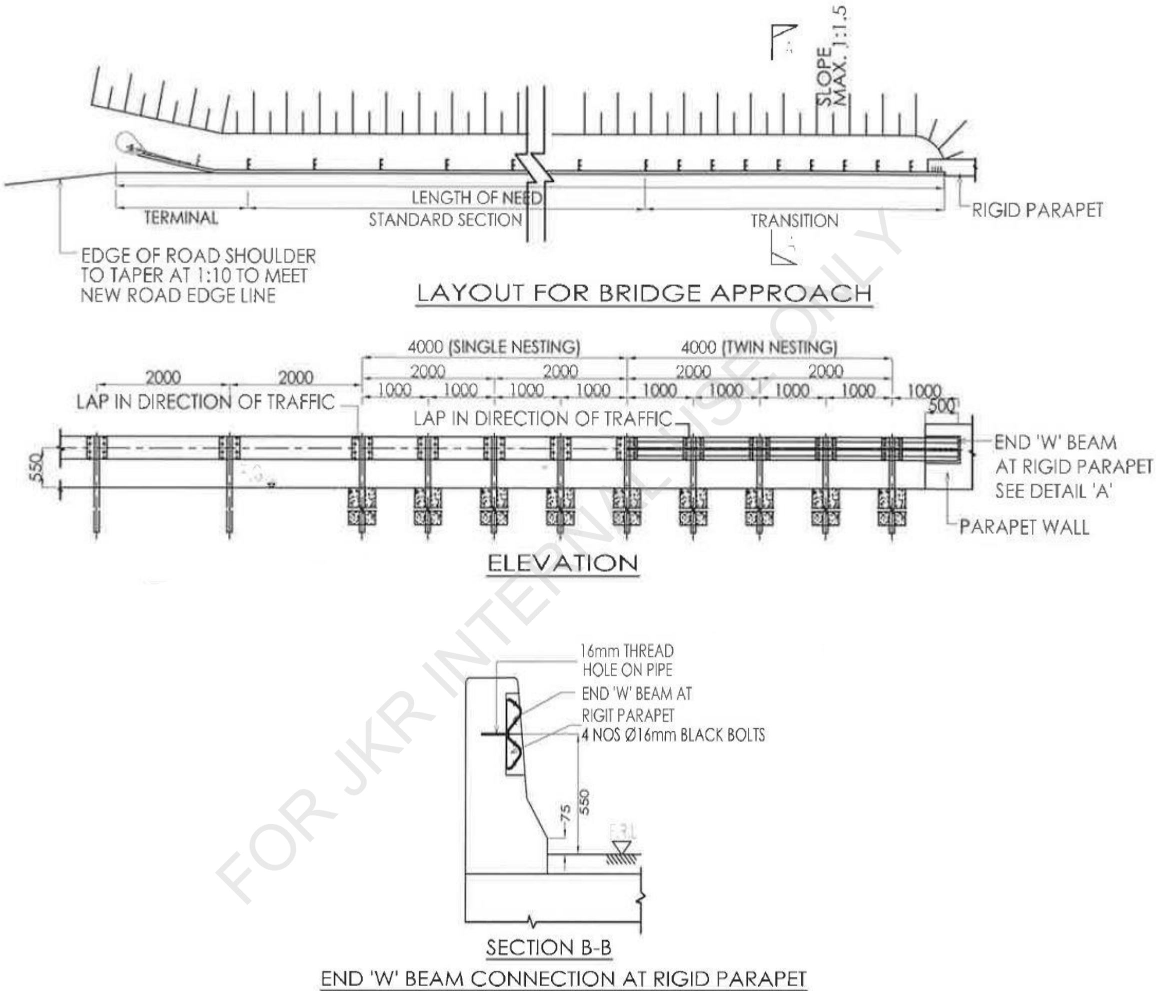


Figure P9: Treatment at Bridge Approach

Road Safety Barriers

Type Of Safety Barrier based on Test Level

Test Level 2: Roadside and Median Barriers

1. Weak-post W-beam Guardrail
2. Strong Post (Steel) W-beam Guardrail w/steel block

Test Level 3: Roadside and Median Barriers

1. Weak-Steel Post Cable (3-Strand) Guardrail
2. Weak-Post Box-beam Guardrail and Median Barrier
3. Strong-Post (Wood) W-Beam Guardrail and Median Barrier w/wood or approved plastic block
4. Strong-Post (Steel) W-Beam Guardrail and Median Barrier w/routed wood or approved plastic block
5. Strong-Post (Wood) Thrie-Beam Guardrail and Median Barrier w/wood or approved plastic block
6. Strong-Post (Steel) Thrie-Beam Guardrail and Median Barrier w/routed wood or routed approved plastic block
7. Merritt Parkway (CT) Steel-backed Timber Guiderail

Test Level 4: Roadside and Median Barriers

1. Strong-Post Modified Thrie-Beam Guardrail and Median Barrier
2. 810-mm tall Safety-Shape (New Jersey) Median Barrier
3. 810-mm tall F-Shape Median Barrier
4. 810-mm tall Vertical Concrete Barrier *
5. 810-mm tall Constant Slope Barrier (TX and CA designs)

Test Level 5: Roadside and Median Barriers

1. 1070-mm tall Safety-Shape (New Jersey) Median Barrier
2. 1070-mm tall F-Shape Median Barrier
3. 1070-mm Ontario Tall Wall Median Barrier
4. 1070-mm tall Vertical Concrete Barrier *
5. 1070-mm tall Constant slope barrier (TX & CA designs) **

Notes:

* these two designs were tested as bridge railings. They may be used as roadside or median barriers if reinforcing and foundation details are equivalent to the crash tested installations.

** the Constant Slope Barriers were not tested to the TL5 level, but may be considered TL5 barriers when cast in place or slip formed if the dimensions, reinforcing, and foundation details are equivalent to designs that have been successfully tested.

Test Level 6: Bridge Railings and TL6 Barriers

The Texas Type TT (Tank Truck) shown here is an extremely strong barrier railing that can successfully contained and redirected a 36000 kg tractor-tank trailer impacting the barrier at 80 km/h at an angle of 15 degrees. This barrier is warranted for use in only the most rare situations. The barrier as tested consists of a **very heavily reinforced and widened concrete safety shape with a massively reinforced continuous concrete member and post.** Total barrier height is 2.290m. Although designed and tested as a bridge railing, this cross-section has also been used as a longitudinal barrier in some locations.

Road Safety Barriers

Criteria for High Risk Locations

Run-off heavy vehicles and buses are not easily retained within the carriageway with W-beam guardrail or simple mass concrete barriers. These vehicles have large masses and high centre of gravity which require safety barriers of extra-ordinary strength such as those under the category of Test Level 5 and 6 (NCHRP 350).

It is not practical to install TL5 or TL6 barrier at any location as the capital cost of such installation is very high. Hence, it is necessary to confine the use of these barriers at specific locations which are considered to be **high risk**.

These high risk locations can be the existing barrier-installed sections of high embankment roads with high possibility of run-off incidences where the use of high strength barriers will be of potential benefit in avoiding severe injuries or even death involving heavy vehicles and buses.

These locations can also be identified based on visible crash evidences such as skid marks on pavement, gouge / scratch on safety barriers or any visible roadside damages. Spot speed study can be used as an additional tool for the investigation. However, the basic criteria to identify high risk locations for installation of TL5 or TL6 barriers are basically as follows:

Criteria 1: the height of embankment must be more than 3m;
Criteria 2: the slope of the embankment must be more 1:6;
Criteria 3: the location is accident prone involving heavy vehicles and buses;
Criteria 4: the percentage of heavy vehicles/buses plying along the road is more than the national average.

Designer has the option of considering all the criteria mentioned above or select any of the following combinations below:

Option 1: Combination of Criterion 1, 2 and 3
Option 2: Combination of Criterion 1, 2 and 4

Road Safety Barriers

Comparing Barrier Test Level Standards

Table P5 : Comparison between requirement for test level in NCHRP 350 and MASH 2009

	BARRIERS TEST STANDARDS		
Test Standard	**NCHRP 350**	**MASH 2009**	**EN 1317-2**
Test levels	6	6	11
Small Car (Kg)	820	1100	900, 1300, 1500
Pick-up truck (Kg)	2000	2270	No
Bus (Kg)	No		13000
Truck (Kg)	8000SU, 36000V & 36000T	10000SU & 36000V	10000S, 16000, 30000 & 38000
Gating terminals and crash cushion impact angle	15 Degrees	5 Degrees	15 & 165 Degrees
Support structure and work zone traffic control device testing	Only small car tested	Small car and light truck tested	NA
Test speed Km/h	50, 70, 100	50, 70, 80, 90, 100	65, 70, 80, 100, 110
Approach angle	15, 20 & 25	15 & 25	8, 15 & 20

Any longitudinal barrier to be installed along the roadway must meet the recognized performance standard including the anticipated protection during a crash before it is accepted for use.

The international acknowledged testing criteria for longitudinal barriers is NCHRP 350 (United States and Australia), MASH and EN 1317-2 (Europe standard). MASH or 'The Manual for Assessing Safety Hardware (MASH)' was introduced in 2009 to supersede the NCHRP 350. Malaysia still refer to the NCHRP 350 standard as the basis for approval of any type of longitudinal barrier but may have to subsequently adopt MASH 2009 in the future. The table above indicated some differences between the three test standards.

MASH 2009 standard is higher compare to NCHRP 350 due to higher vehicle mass, test speed and angle of impact which greatly changed the impact severity level as well as the test level.

Here are some of the more significant changes from the NCHRP 350 conditions to the MASH 2009 conditions:

1. Small car increases from 820 kg. to 1,100 kg.
2. Small car impact angle changed from 20 to 25 degrees.
3. Pickup truck increases from 2,000 kg. to 2,270 kg.
4. TL-4 truck increases from 8,000 kg. to 10,000 kg.
5. TL-4 truck speed changed from 80 km/h to 90 km/h.
6. Terminal & Crash Cushion impact angle changed from 20 to 25 degrees.

Road Safety Barriers

Impact Severity and Test Matrices

Impact Severity (IS)

This is an index that assesses the severity of an impact against the tested restraint system based on the results of different parameters. The impact severity is divided in 3 levels, from A to C, in increasing order of severity of the consequences of the impact on the car's occupant. Impact severity is calculated by assessing two components: the Acceleration Severity Index and the Theoretical Head Impact Velocity.

Acceleration Severity Index (ASI) is the main parameter for the calculation of the Impact Severity and is calculated by placing an accelerometer in the centre of the mass of the car and recording the impact against the road restraint system. It is computed all along the impact time and its maximum value is used to evaluate the severity of the impact.

Theoretical Head Impact Velocity (THIV) is for assessing the occupant impact severity for vehicles involved in collisions with road restraint systems. The occupant is considered to be a freely moving object (head) that, as the vehicle changes its speed during contact with the road restraint system, continues moving until it strikes a surface within the interior of the vehicle. The magnitude of the velocity of the theoretical head impact is considered to be a measure of the vehicle to road restraint system impact severity.

Table P6: Impact Severity Level

Level of Class	Maximum Permissible Values	
A	ASI $\leq$ 1.0	THIV $\leq$ 33 km/h
B	1.0 < ASI $\leq$ 1.4	THIV $\leq$ 33 km/h
C	1.4 < ASI $\leq$ 1.9	THIV $\leq$ 33 km/h

Table P7: Test Matrices for Longitudinal Barrier

Test Level	Barrier Section[c]	Test No.	Vehic.	Impact Speed,[a] mph (km/h)	Impact Angle,[a] θ, deg.	Im-pact Point	Acceptable IS Range,[a] kip-ft (kJ)	Evaluation Criteria[b]
1	Length-of-need	1-10	1100C	31 (50.0)	25	(c)	≥13 (17.4)	A,D,F,H,I
		1-11	2270P	31 (50.0)	25	(c)	≥27 (36.0)	A,D,F,H,I
	Transition	1-20[d]	1100C	31 (50.0)	25	(c)	≥13 (17.4)	A,D,F,H,I
		1-21	2270P	31 (50.0)	25	(c)	≥27 (36.0)	A,D,F,H,I
2	Length-of-need	2-10	1100C	44 (70.0)	25	(c)	≥25 (34.2)	A,D,F,H,I
		2-11	2270P	44 (70.0)	25	(c)	≥52 (70.5)	A,D,F,H,I
	Transition	2-20[d]	1100C	44 (70.0)	25	(c)	≥25 (34.2)	A,D,F,H,I
		2-21	2270P	44 (70.0)	25	(c)	≥52 (70.5)	A,D,F,H,I
3	Length-of-need	3-10	1100C	62 (100.0)	25	(c)	≥51 (69.7)	A,D,F,H,I
		3-11	2270P	62 (100.0)	25	(c)	≥106 (144)	A,D,F,H,I
	Transition	3-20[d]	1100C	62 (100.0)	25	(c)	≥51 (69.7)	A,D,F,H,I
		3-21	2270P	62 (100.0)	25	(c)	≥106 (144)	A,D,F,H,I
4	Length-of-need	4-10	1100C	62 (100.0)	25	(c)	≥51 (69.7)	A,D,F,H,I
		4-11	2270P	62 (100.0)	25	(c)	≥106 (144)	A,D,F,H,I
		4-12	10000S	56 (90.0)	15	(c)	≥142 (193)	A,D,G
	Transition	4-20[d]	1100C	62 (100.0)	25	(c)	≥51 (69.7)	A,D,F,H,I
		4-21	2270P	62 (100.0)	25	(c)	≥106 (144)	A,D,F,H,I
		4-22	10000S	56 (90.0)	15	(c)	≥142 (193)	A,D,G
5	Length-of-need	5-10	1100C	62 (100.0)	25	(c)	≥51 (69.7)	A,D,F,H,I
		5-11	2270P	62 (100.0)	25	(c)	≥106 (144)	A,D,F,H,I
		5-12	36000V	50 (80.0)	15	(c)	≥404 (548)	A,D,G
	Transition	5-20[d]	1100C	62 (100.0)	25	(c)	≥51 (69.7)	A,D,F,H,I
		5-21	2270P	62 (100.0)	25	(c)	≥106 (144)	A,D,F,H,I
		5-22	36000V	50 (80.0)	15	(c)	≥404 (548)	A,D,G
6	Length-of-need	6-10	1100C	62 (100.0)	25	(c)	≥51 (69.7)	A,D,F,H,I
		6-11	2270P	62 (100.0)	25	(c)	≥106 (144)	A,D,F,H,I
		6-12	36000T	50 (80.0)	15	(c)	≥404 (548)	A,D,G
	Transition	6-20[d]	1100C	62 (100.0)	25	(c)	≥51 (69.7)	A,D,F,H,I
		6-21	2270P	62 (100.0)	25	(c)	≥106 (144)	A,D,F,H,I
		6-22	36000T	50 (80.0)	15	(c)	≥404 (548)	A,D,G

ROAD INTERSECTION DESIGN

Road Intersection Design

Traffic Signal Control

Traffic signal control is to provide for a safe and efficient traffic flow through intersections, along routes and in road networks. At individual intersections, the primary purpose is to assign right-of- way for alternate roads or road approaches in order to maximize capacity, minimize delay and reduce conflicts.

Traffic control signals should generally not be installed unless one or more of the warrants in this guideline is met:

- Warrant No. 1: 8-Hour Volume
- Warrant No. 2: Peak Hour / 1-Hour Volume
- Warrant No. 3: Coordinated Signal System
- Warrant No. 4: Pedestrian Safety
- Warrant No. 5: Accident Experience

In general, the following steps should be taken prior to the installation of traffic signal control:

a. Function of the intersection as it relates to the overall road system. Intersection controls must be related to the major road system.
b. A study of traffic data and physical characteristics of the location to determine the need for signal control and for the proper design and operation of the control.
c. Determine if the geometric or physical improvements or regulations will provide a better solution to the problem of safety or efficiency than the installation of signal control.
d. Use established warrants to determine if intersection control is justified.

Table G32: Vehicular Volume Requirements for Warrant No. 1

Number of Lanes at Each Approach		Minimum Requirements (vph)			
		Major Road *		Minor Road **	
Major Road	Minor Road	Urban	Rural	Urban	Rural
1	1	500	350	150	105
2 or more	1	600	420	150	105
2 or more	2 or more	600	420	200	140
1	2 or more	500	350	200	140

Notes:
* Total volume of both approaches
** Higher volume approach only

Road Intersection Design

Traffic Signal

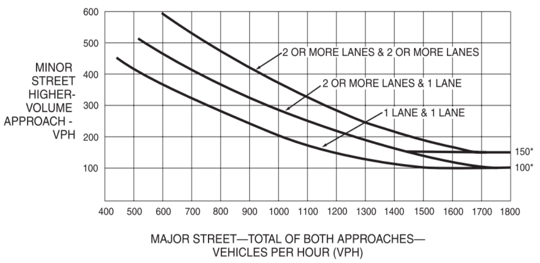


Figure G24: Peak Hour Volume Warrant - Urban or Low Speed

* Note: 150 vph applies as the lower threshold volume for a minor road approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor road approach with one lane

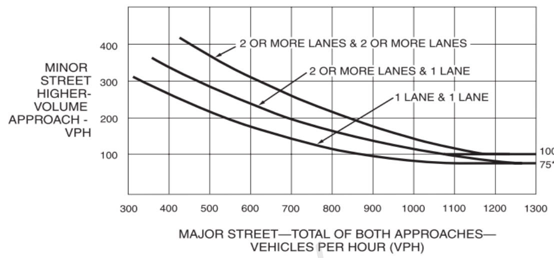
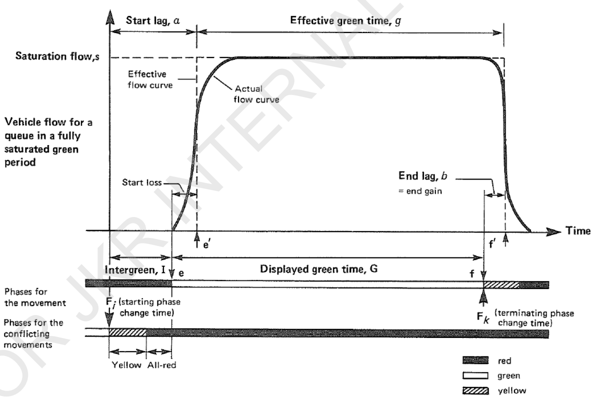


Figure G25: Peak Hour Volume Warrant - Rural or High Speed

* Note: 100 vph applies as the lower threshold volume for a minor road approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor road approach with one lane.



Ensure that the final design is optimised by reducing any possible delay. Hence, the following design objectives must be observed:

1. Minimise cycle time
2. Minimise the number of phases
3. Run compatible movements during each phase to minimise conflicts
4. Allow each movement to run in as many phases as possible

The graph on the left shows a single phase of a traffic flow as a function of time. A signal phase is a state of signals during which one or more movements receive right-of-way. When there is a change in the right-of-way there is a phase change. A phase is therefore identified by movements gaining right-of-way and then losing right-of-way.

A signalised intersection consists of more than one signal phase which operates in sequence. One complete sequence of signal phases is called a signal cycle.

Road Intersection Design

Selection of Intersection Type

The controlled priority of an at-grade intersection will normally provide adequate capacity for the traffic flows expected in most intersection. Where the predicted traffic flows exceed the capacity, other types of intersection have to be introduced. These are:

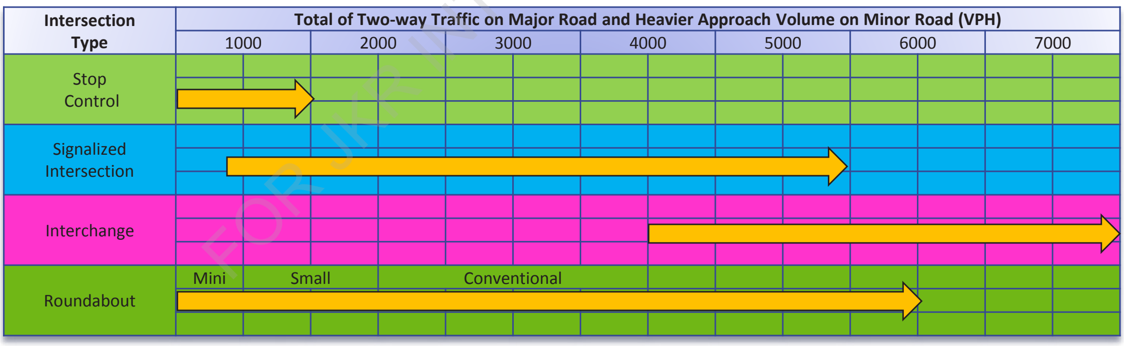
a. Roundabouts
b. Signal Controlled Intersections
c. Grade separated Intersections or Interchanges

The fundamental factor which decides the type of intersection is traffic volume. Other factors such as class of road, lane configuration should also be taken into account, especially when the traffic volume falls near the boundary of the applicable range of an intersection type.

Roundabouts may be applicable for total traffic volume (sum of all directions) of up to 6000 vehicles/hour and may if the layout can be freely chosen, be designed to cater for any distribution of turning traffic.

The roundabout can be signalized once it exceeds the capacity per leg (6,000 veh/h), if it is so required. A roundabout design can also accommodate for future expansion if any of its approaches reaches its saturation capacity level, that is by converting it into an interchange such as flyover or ramp to relief the traffic congestion for the particular approach inside the roundabout.

Table G33: Selection Of Intersection Type



Roundabouts are usually ranged in size as follows

a. Mini - Less than 20 meter (in diameter of inscribed circle); Less than 4 meter (in diameter of center circle)
b. Small - 20 to 50 meter; 4 to 25 meter
c. Conventional - More than 50 meter; More than 25 meter

Road Intersection Design

Design Vehicles and Spacing of Intersection

Design Vehicles for Intersection Design

The design of the various intersection layouts should be made for the design vehicles P, SU or WB-15. The table on the right shows a general scheme to select the design vehicle according to the category of road.

- For intersection formed by roads of different design vehicles, the higher design should primarily be chosen. If the frequency of turns made is small, the lower design vehicle may be used.
- Design vehicle, P is normally applicable only to intersection of two local streets or minor roads carrying low volumes.

Table G34: Design Vehicle For Intersection Design

Area	Category of Roads	Design Vehicles
Rural	Expressway	WB-15
	Highway	
	Primary	
	Secondary	SU
	Minor	SU / P
Urban	Expressway	WB-15
	Arterial	
	Collector	SU
	Local Street	SU / P

Spacing of Intersections

The spacing of intersections depends on factors such as weaving distance and, storage length required for queueing traffic at signalised intersections and the lengths of right turning lanes.

The table gives the desirable minimum spacings of intersections for the various categories of the major roads.

V = Design Speed in km/h

n = no. of through lane in one direction

Table G35: Minimum Spacing of Intersection

Area	Category of Major Road	Spacing (m)
Rural	Expressway	3,000
	Highway	V x 20
	Primary	V x 10
	Secondary	V x 5
	Minor	V x 3
Urban	Expressway	1,500
	Arterial	V x 3 x n
	Collector	V x 2 x n
	Local Street	V x 1.5 x n

Road Intersection Design

Provision of Right Turn Lane and U-Turn Facilities

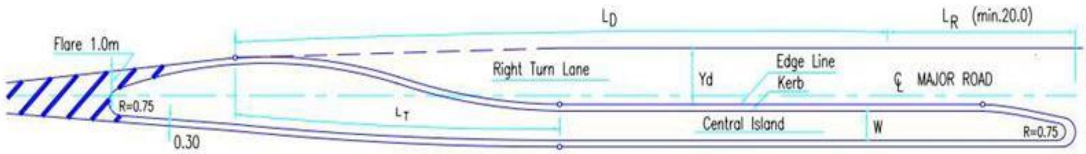


Figure G26: Protected Right Turn Lane Facility

Table G36: Deceleration Length (L_D)

Gradient (%)		Design Speed, V (km/h)						
		20	30	40	50	60	80	100
Uphill	4	20	28	41	54	72	108	153
	2	20	30	45	60	80	120	170
Level	0	20	30	45	60	80	120	170
Downhill	2	20	30	45	60	80	120	170
	4	20	34	53	72	96	144	204

Length of Taper, LT = $\frac{1}{3}V(Yd)^{1/2}$

where

Yd = width of right turn lane

W = width of central island

Direct U-Turn Facility

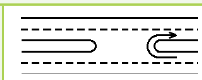
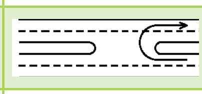
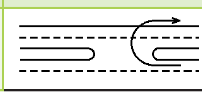
The tables below show the desirable distance between U-turn and minimum width of median for various design vehicles. Both tables can also be used as guide for indirect U-turn facility.

It may be necessary to provide protected lane for the U-turn facility from the fast moving through traffic similar to that for the right turn provision above.

Table G37: Distance Between U-Turns

Area	Design Standard	Distance Between U- Turns
Rural	R6	No U-turn allowed
	R5	3 km
	R4	2 km
Urban	U6	No U-turn allowed
	U5	2 km
	U4	1 km
	U3	1 km

Table G38: Minimum Width for Median

Type of Maneuver		Min width of Medium for Design Vehicle		
		P	SU	WD-5
Inner lane to inner lane		9.75	19.50	21.25
Inner lane to outer lane		6.00	15.75	17.75
Inner lane to shoulder		3.00	12.75	14.50

Road Intersection Design

Length of Deceleration Lane

Table G39: Length of Deceleration Lane

Design Speed of Approach Road (km/h)	Length* of Deceleration Lane (m) (including length of tapered approach) Where design speed of exit curve (km/h) is						
	0**	20	30	40	50	60	80
40	45	40	32	-	-	-	-
50	60	54	46	32	-	-	-
60	80	74	64	50	28	-	-
80	120	112	104	94	82	64	-
100	170	162	154	144	132	118	80

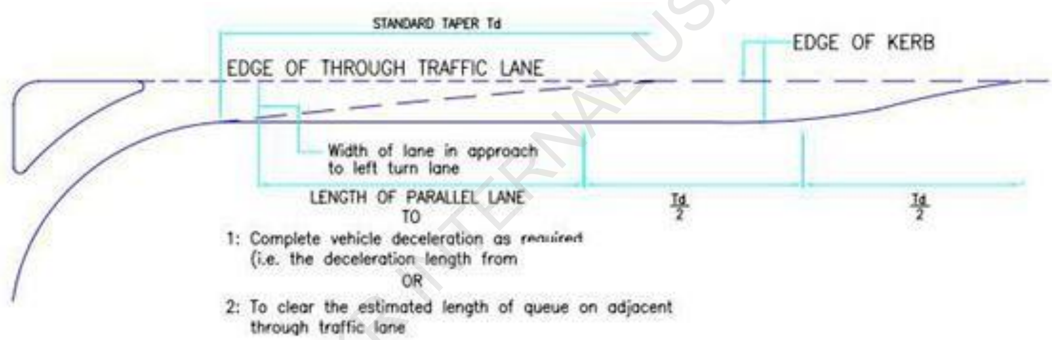


Figure G27

* Length for level grade (see correction for grade)

** Length required when a vehicle decelerates to zero speed

The length of these auxiliary lanes may be extended or shortened depending on whether the deceleration or acceleration is on a down grade or up grade

Road Intersection Design

Length of Acceleration Lane

Table G40: Length of Acceleration Lane

Design Speed of Road Being Entered (km/h)	Length* of Acceleration Lane (m) (including length of pavement taper) where design speed of exit curve (km/h) is					
	0**	20	30	40	50	60	80
40	65	45	35	-		-	-
50	95	75	60	40	-	-	-
60	135	120	100	75	40	-	-
80	230	215	200	180	145	100	-
100	330	315	295	275	250	205	100

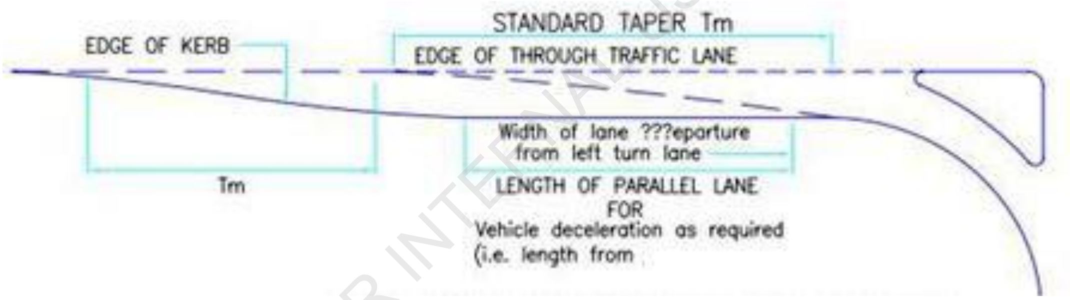


Figure G28

* Length for level grade (see correction for grade)
** Length required when a vehicle decelerates to zero speed

The length of these auxiliary lanes may be extended or shortened depending on whether the deceleration or acceleration is on a down grade or up grade

Road Intersection Design

Determination of Interchange Type

General Design Considerations for Interchange Type

The type of interchange will vary with the terrain, development along the highway, and right-of-way conditions, but in general it will be based on ramp layouts to expedite entrance to or exit from the expressway. Ramp connections may also involve frontage roads.

(a) Systems Interchanges and Service Interchanges

Interchange types are covered in two categories, i.e. : "systems interchanges" and "service interchange". Systems interchanges are used to identify interchanges that connect expressway to expressway while the term service interchange applies to interchanges that connect expressways to lesser facilities.

(b) Interchanges in Rural Area

In rural areas, the problem of interchange type selection is solved on the basis of service demand. When the intersecting roadways are expressways, all directional interchanges may be in order for high turning volumes.

A cloverleaf interchange is the minimum design that can be used at the intersection of two fully controlled access facilities or where right turns at grade are prohibited. A cloverleaf interchange is adaptable in a rural environment where right-of-way is not prohibitive and weaving is minimal.

The final configuration of an interchange may be determined by the need for route continuity, uniformity of exit patterns, single exit in advance of the reparation structure, elimination of weaving on the main facility, signing potential, and availability of right-of- way.

(c) Interchange In Urban Area

Generally, in urban areas, interchanges are so closely spaced that each interchange may be influenced directly by the preceding or following of interchange to the extent that additional traffic lanes may be required to satisfy capacity, weaving and lane balance.

On a continuous urban route all the interchanges should be integrated into a system design rather than considered on an individual basis. Generally, cloverleaf interchanges with or without collector-distributor road are not practicable for urban construction because of the excessive right-of-way requirements.

(d) Factors for Type Determination

Once several alternatives have been prepared for the system design, they can be compared on the following principles:

1. capacity,
2. route continuity,
3. uniformity of exit patterns,
4. single exits in advance of the separation structures,
5. with or without weaving,
6. potential for signing,
7. cost,
8. availability of right-of-way,
9. potential for stage construction, and
10. compatibility with the environment.

The most desirable alternatives can be retained for plan development. The figure on the following page depicts interchanges that are adaptable on expressways as related to classifications of intersecting facilities in rural and urban environments.

Road Intersection Design

Type of Intersecting Facility and Design Elements

Table G41: Type of Interchange Facility based on Development Area and Category of Road

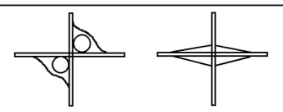
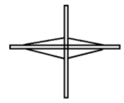
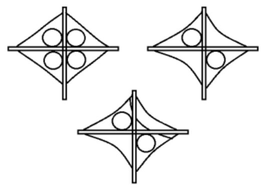
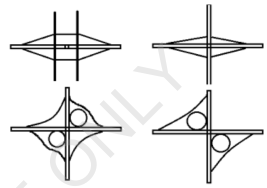
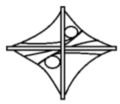
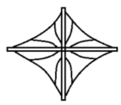
Type of Interchange		Rural	Urban
Local Street or Minor Roads	Service Interchange		
Collector / Arterial or Secondary Roads	Service Interchange		
Expressways	System Interchange		

Table G42: Desirable Lowest De Through Highways at Interchange Area

Highway Design Speed (km/h)	Minimum Radius (m)	Maximum Gradient (%)	Minimum Vertical Curve Length in K-Value	
			Crest	Sag
120	2000	2	450	160
100	1500	2	250	120
80	1000	3	120	80
60	500	4.5	60	40
50	300	5	40	30

Interchange Spacing

In areas of concentrated urban development, proper spacing usually is difficult to attain because of a traffic demand forfrequent access. Minimum spacing of arterial interchanges (distance between intersecting street with ramps) is determined by weaving volumes, ability to sign, signal progression, and required lengths of speed change lanes.

A generalised rule of thumb for minimum Interchange spacing is 1.5km in urban areas and 3.0km in rural areas. In urban areas, spacing of less than 1.5km may be developed by grade separated ramps or by adding collector distributor roads. On urban expressways, connection to the arterial is often made with a single independent ramp rather than with an interchange of full. Where independent ramps on different streets are closely and irregularly arranged on the expressway, the distance between ramp terminal must also be examined.

Road Intersection Design

Minimum Acceleration and Deceleration Lengths for Interchange Terminals

Table G43: Minimum Acceleration Length for Entrance Terminals

Highway Design Speed (km/h)	Acceleration Length, L (m) for Entrance Curve Design Speed (km/h)								
	Stop Condition	**25**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
50	60	-	-	-	-	-	-	-	-
60	115	100	75	65	40	-	-	-	-
80	235	215	190	180	150	115	50	-	-
100	360	325	330	300	275	245	180	120	50
120	485	470	460	430	405	375	310	250	180

Table G44: Taper Length of Parallel Type Acceleration Lane

Highway Design Speed (km/h)	Taper Length (m)
50	50
60	60
80	70
100	80
120	90

Table G45: Minimum Deceleration Length for Exit Terminals

Highway Design Speed (km/h)	Acceleration Length, L (m) for Exit Curve Design Speed (km/h)								
	Stop Condition	**25**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
50	70	55	50	45	-	-	-	-	-
60	95	90	80	70	60	50	-	-	-
80	130	125	120	110	95	85	70	55	-
100	160	155	150	140	130	125	105	90	75
120	190	180	175	170	155	150	130	120	105

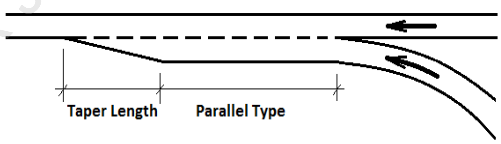


Figure G29: Acceleration with Parallel Lane

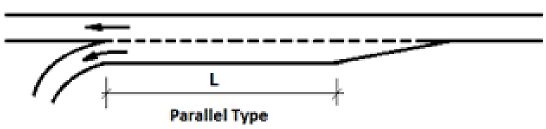


Figure G30: Deceleration with Parallel Lane

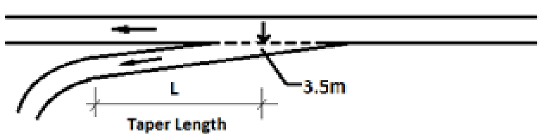


Figure G31: Deceleration with Taper

PAVEMENT DESIGN

Pavement Design

Pavement Design

Introduction

- A pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution.
- The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the subgrade.
- Two types of pavements are generally recognized as serving this purpose, namely:
  1. Flexible Pavements
  2. Rigid Pavements

Principles of Pavement Design

- Tensile and compressive stress due to traffic load decrease with increasing depth - allow the use of stronger materials on top and less stronger/ cheaper ones at the bottom.
- Pavement as a whole must limit the stress in the subgrade to an acceptable level.
- Each layer of the pavement must be able to support the machinery placing the material above.
- Need to develop the most economical combination of pavement layers to suit soil condition and projected traffic.

Input For Pavement Design

The following key information is needed for design of flexible pavements:

- Types and volumes of commercial vehicles for which the pavement structure is designed.
- Design life.
- Sub-grade type and strength.
- Types and properties of paving materials used.
- Environment to which the pavement structure will be exposed.

Typical Flexible Pavement Structures

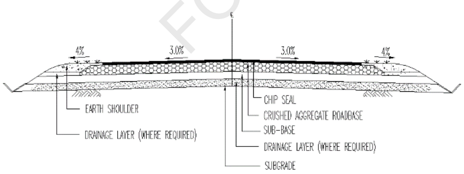


Figure N1: Single Carriageway – Minor Road/Low-Volume Road

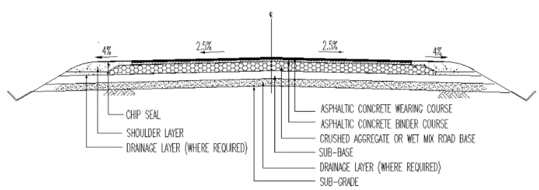


Figure N2: Single Carriageway – Major Road

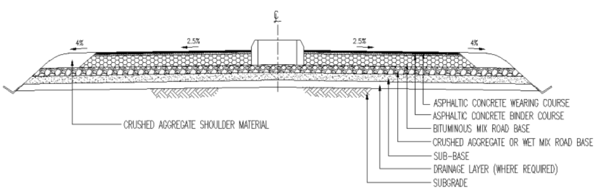


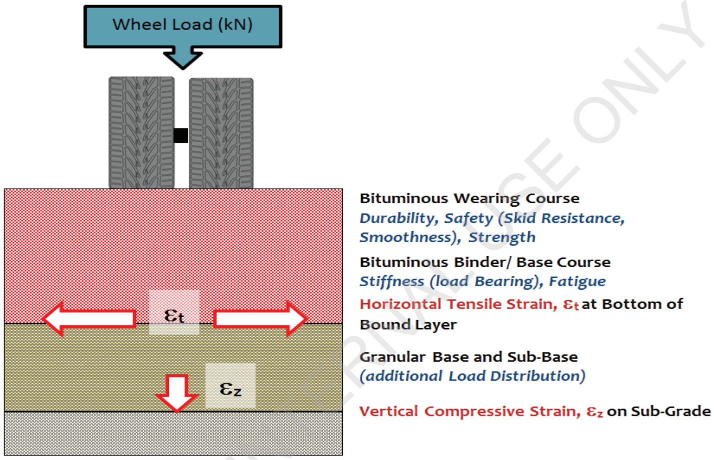
Figure N3: Dual Carriageway – Major Road

Pavement Design

Pavement Design Methodology

The design procedure used in this Guideline is based on traditional concepts of pavement design, which is based on the assumption that the following two strains are critical to pavement performance : -

- Vertical strain ε_Z on top of the sub-grade.
- Horizontal strain ε_t at the bottom of the lowest bound pavement course.



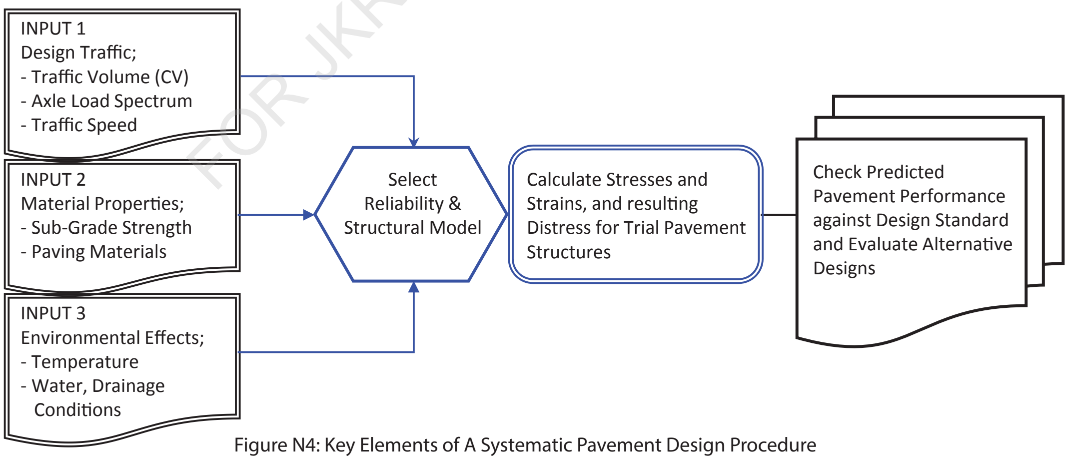


Figure N4: Key Elements of A Systematic Pavement Design Procedure

Pavement Design

Flexible Pavement

Flexible asphalt pavement must be constructed with sufficient thickness based on the design for a one-way daily traffic of heavy vehicles and the design CBR of the subgrade soil. Generally, surface and subgrade drainage should also be designed together with the pavement structure.

The pavement structure above the subgrade may consists of several layers as shown in the figure below. A filter layer may also be laid as part of the subgrade to prevent subgrade soil from intruding into the subbase course. The layers are:

Subgrade is a soil or rock formation that forms the foundation of a pavement structure; it consists of a prepared cut or compacted fill. The pavement structure shall be designed so that stresses and strains due to traffic loads on the sub-grade remain within tolerable limits. These limits are a function of the elastic stiffness and bearing capacity of the sub-grade and of the traffic volume that a pavement is designed for. When required and specified, weak sub-grade materials shall be replaced with selected materials or stabilised up to depth of at least 300 mm below sub- grade level to provide a suitable platform for construction traffic and a sound foundation for the pavement. Sub-grade improvement shall not be considered as a separate layer in mechanistic pavement design. The strength of the subgrade is a basic factor in determining the thickness of the pavement and is evaluated by means of CBR tests. The proposed minimum soaked CBR for subgrade is $\geq$ 5%.

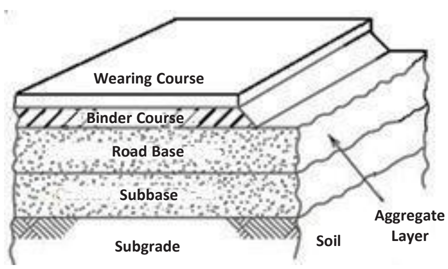
Subbase Course shall consist of a layer of specified material composition, stiffness and thickness placed directly on the sub- grade. Sub-base shall be considered as lower road base that supports the upper road base and that aids in distributing traffic induced stresses. Because stress levels are lower in the sub-base course than in the road base, sub-base materials are usually of lower quality and stiffness than materials used as road base.

Road base is the main structural layer of a pavement. In flexible pavements, it shall consist of bituminous mixtures, or a granular layer stabilised with cement, emulsion, or similar materials, or mechanically stabilised but otherwise unbound crushed aggregate road base or wet-mix road base. Its key function is to distribute traffic loads so that sub-base and sub-grade are not subjected to excessive stresses and strains.

Binder Course is usually considered part of the surface layers of a pavement. A binder course shall have good resistance to shear- induced distress, because shear stress is highest at a depth of about 0.9 times the radius of the contact area of a wheel load, which corresponds in the case of most commercial vehicles to a depth of about 8 to 12 cm below the pavement surface.

Wearing Course shall meet both structural (resistance to stresses and strains imposed by traffic loads) and functional performance requirements; the latter includes adequate durability (resistance to the disintegrating effects of climate), good frictional characteristics and smoothness.

Shoulder is the part of a road next to the carriageway and is for securing lateral clearance. The functions of this clearance are to protect major structures on the roads, and to secure safety and comfort for traffic and pedestrians.



Pavement Design

Properties of Pavement Layers

Properties of Sub-Grade

Sub-Grade Category	CBR (%)	Elastic Modulus (MPa)	
		Range	Design Input Value
• SG 1	5 to 12	50 to 120	60
• SG 2	12.1 to 20	80 to 140	120
• SG 3	20.1 to 80.0	100 to 160	140
• SG 4	> 30.0	120 to 180	180

Properties of Paving Materials

The categories include (from top of the pavement downwards):

- Bituminous wearing and binder courses.
- Bituminous road base.
- Unbound granular road base.
- Cemented or otherwise stabilised road base.
- Unbound granular sub-base.

Elastic Properties of Unmodified Bituminous Mixtures

BItuminous Mixture based on PMB	Elastic Modulus (MPa)		Poisson's Ratio	
	25°c	35°c	25°c	35°c
• Wearing Course AC 10 and AC 14	----	1200	0.35	0.40
• Wearing Course SMA 14 and SMA 20	----	1200	0.35	0.40
• Binder Course AC 28	2000	1600	0.35	0.40
• Road Base AC 28	2000	---	0.35	---

Elastic Properties of Polymer Modified Bituminous Mixtures

BItuminous Mixture based on PMB	Elastic Modulus (MPa)		Poisson's Ratio	
	25°c	35°c	25°c	35°c
• Wearing Course AC 10 and AC 14	----	1400	0.35	0.40
• Wearing Course SMA 14 and SMA 20	----	1400	0.35	0.40
• Binder Course AC 28	2500	2000	0.35	0.40
• Road Base AC 28	2500	---	0.35	---

Stabilised Road Base

JKR Standard Specifications for Road Works, JKR/SPJ/2008 –
Section 4 include the following types of stabilised road base: -

- Aggregates stabilised primarily with cement or lime (STB 1).
- Aggregates stabilised primarily with a combination of bituminous emulsion/foamed bitumen and cementitious material (STB 2).

For the design of pavement structures included in the catalogue of the JKR ATJ 5/85 (Revision 2013), the following elastic modulus and Poisson's ratio values were assumed: -

STB 1: Stabilised base with 3% to 5% Portland cement.

$$E = 1800 \text{ MPa}; v = 0.35$$

STB 2: Stabilised base with bituminous emulsion or foamed bitumen and a maximum of 2% Portland cement.

$$E = 1200 \text{ MPa}; v = 0.40$$

Pavement Design

Pavement Design Procedure

Pavement Design Procedure

Steps in Pavement Design (based on JKR ATJ 5/85 – Revision 2013):

1. Determine subgrade support .
2. Calculate traffic design loading.
3. Use catalogue structure todetermine the required pavement layer thickness.

Calculation of the traffic design load in million standard axle (msa):

$$\mathbf{V_c = V_0\,[(1+r)^n - 1] / r}$$

where,

V_0 = first year volume of commercial vehicle
V_c = final volume of commercial vehicle
r = traffic growth
n = design life

Note:

- Traffic is based on **one way traffic** volume in a year.
- **Equivalent Standard Axle Load (ESAL)** – 80 KN (8.16 tonne)
- **Load Equivalent Factor (LEF)** depends on the percentage of heavy goods vehicle and type of vehicle.

The total design loading (msa):
= final volume x Equivalent Factor
= $\mathbf{V_c}$ **x LEF**

Pavement Rehabilitation Design

1. Evaluate existing pavement condition.
2. Calculate traffic design loading.
3. Determine the required thickness, T_A for the calculated design loading.
4. Determine existing equivalent thicknessT_e using:
   $\mathbf{T_e = h_1a_1 + h_2a_2 + h_3a_3 \ldots\ldots h_na_n}$ where,
   $h_1 \ldots\ldots h_n$ = existing layer thickness
   $a_1 \ldots\ldots a_n$ = existing structural layer coefficient
5. Calculate the overlay thickness = T_A - T_e

Figure N5: Picture showing the weight distribution on the axles (*1000 Kg = 1 Tonne).

Pavement Design

Flexible Pavement Structure

Table N1: Conceptual Outline of Pavement Structures used in Guideline JKR ATJ 5/85 – Revision 2013

Pavement Structure	Traffic Category (based on million ESALs @ 80 kN)				
	≤ 1	*1 to 2*	*2.1 to 10*	*10.1 to 30*	*> 30*
	T 1	T 2	T 3	T 4	T 5
Combined Thickness of Bituminous Layers	5 cm	10 cm	18 cm	20 cm	24 cm
Crushed Aggregate Road Base + Sub-Base for Sub-Grade CBR of:					
○ 5 to 12	25+15 cm	20+15 cm	20+20 cm	NR	NR
○ 12.1 to 20	20+15 cm	20+15 cm	20+20 cm	20+20 cm	20+20 cm
○ 20.1 to 30	20+10 cm	20+10 cm	20+15 cm	20+15 cm	20+15 cm
○ > 30	20 cm	20+10 cm	20+10 cm	20+10 cm	20+10 cm

Types of Standardised Pavement Structures

- Pavement structures shown in Catalogue of Pavement Structures are divided into the following three groups: -
- Conventional flexible pavement with granular base.
- Deep-strength flexible (composite) pavement with bituminous surface course(s) and a base stabilised with Portland cement, bituminous emulsion, or a combination of both.
- Full-depth asphalt pavement with bituminous base course.

Pavement Design

Catalogue of Pavement Structures

Table N2: Steps For Pavement Design

Pavement Structures for Traffic Category T 3: 2.0 to 10.0 million ESALs (80 kN)

Pavement Type	Sub-Grade Category			
	SG 1: CBR 5 to 12	SG 2: CBR 12.1 to 20	SG 3: CBR 20.1 to 30	SG 4: CBR > 30
Conventional Flexible: Granular Base	BSC: 50 BC: 130 CAB: 200 GSB: 200	BSC: 50 BC: 130 CAB: 200 GSB: 200	BSC: 50 BC: 130 CAB: 200 GSB: 150	BSC: 50 BC: 130 CAB: 200 GSB: 100
Deep Strength: Stabilised Base	BSC: 50 BC: 100 STB 1: 150 GSB: 200	BSC: 50 BC: 100 STB 1: 150 GSB: 150	BSC: 50 BC: 100 STB 1: 100 GSB: 150	BSC: 50 BC: 100 STB 1: 100 GSB: 100
Full Depth: Asphalt Concrete Base	BSC: 50 BC/BB: 160 GSB: 200	BSC: 50 BC/BB: 150 GSB: 150	BSC: 50 BC/BB: 130 GSB: 150	BSC: 50 BC/BB: 130 GSB: 100

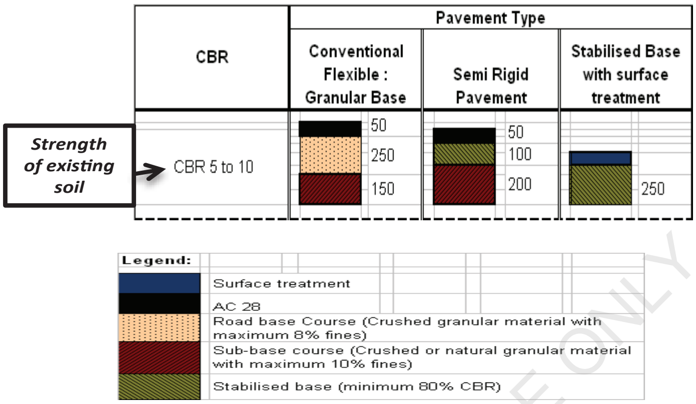
Catalogue of Pavement Structures (JKR ATJ 5/85 – Revision 2013)

A Catalogue from which pavement structures can be selected for a range of sub-grade support conditions and traffic volumes in liaison with the desired pavement type.

The following are the steps to use this catalogue:

Step 1: Determine the Traffic Category based on the calculated traffic design loading.
Step 2: Determine the Sub-Grade Category based on design input.
Step 3: Choose the pavement type.
Step 4: Select the pavement structures.

Table N3: Alternative Pavement Structures Using Stabilising Agent



Soil Stabilisation

Soil stabilisation is employed to subgrade at formation level usually to improve subgrade material properties. By rectifying deficiencies in subgrade materials, stabilisation allows otherwise unsuitable materials to be used to advantage in subgrade or road base.

Stabilisation should benefit to improved soil load bearing capacity to form a new road base and achieve proposed road structure design life thus reducing possibility of having structure defects like rutting, potholes and corrugating during operation.

The correct use of stabilisation requires that the materials property for improvement be clearly identified. The most important properties are strength, stability, permeability, workability and durability.

Low Volume Road Pavement

Table N4: Low Volume Pavement Structure

Sub-Grade (CBR %)	Elastic Modulus (MPa)		Poisson's Ratio
	25°c	35°c	25°c
• 5 to 12	40mm BSC 200mm CAB 150mm GSB	50mm BSC 200mm CAB 150mm GSB	50mm BSC 250mm CAB 150mm GSB
• 12.1 to 20	40mm BSC 200mm CAB 150mm GSB	50mm BSC 200mm CAB 100mm GSB	50mm BSC 200mm CAB 150mm GSB
• ≥ 20	40mm BSC 200mm CAB 100mm GSB	50mm BSC 200mm CAB 100mm GSB	50mm BSC 200mm CAB 150mm GSB

Heavy Duty Pavements for Special Applications

Pavements that need to support either sustained heavy loads or channelised repeated load applications that are well in excess of traditional traffic loading patterns should be designed using a mechanistic design methodology in conjunction with special paving materials that offer high strength and stiffness under both dynamic and static loading conditions.

Pavement Design

Rigid Pavement

Rigid pavement consists of concrete slabs which can either be simply plain concrete or reinforced concrete. Typical applications for rigid pavement are high volume traffic lanes, freeway to freeway connections and exit ramps with heavy traffic. There are
3 basic types of rigid pavement:

1. Plain Concrete Pavement (PCP)
2. Jointed Reinforced CP (JRCP)
3. Continuously Reinforced CP (CRCP)

Concrete pavements are highly durable and capable of a long service life with low maintenance cost. They can withstand repeated flooding and subsurface water without deterioration. Typical layers of concrete pavement are as shown below.

Subgrade requirements are similar to that for flexible pavement.

Subbase may also be provided but must achieve minimum CBR value of 30%.

Base Slab is basically a plain lean mix concrete slab with a min. compressive strength of 7.5MPa. Thickness of the base slab is between 100 – 200mm depending on the design requirements. During the process of curing and hardening the base slab is expected to develop cracks that reduce the development of tension stresses when the top slab is constructed.

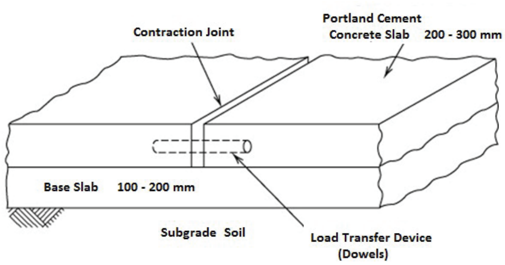
Main Concrete Slab is a 200 – 300mm concrete slab constructed on the base concrete slab. Prior to laying the concrete, a layer of cut-back bitumen emulsion is sprayed evenly on the base slab. This is to remove any friction that will develop between the base slab and the top slab. The slab can either be plain or reinforced concrete. Depending on the design, load transfer dowel bars may be placed at certain interval along transverse contraction joints while tie bars are placed along longitudinal joints. Locations of these joints are predetermined by design.

The concrete slab will crack transversely on the first night, due to cooling and contraction. It will then crack longitudinally, due to curling and transverse contraction. Slabs less than about 5m wide will not crack longitudinally. The transverse contraction joints (at dowels locations) and longitudinal joints are induced by cutting slots at these locations. The cut must be made at the right time if cracks are to develop at these joints. Otherwise cracks may develop on the slab rather than at the cut locations. Sealants are then applied to close up the cracks.

When the top slab is still wet, a texturing equipment is dragged on the surface to roughen the surface to provide the required surface friction. Average texture depth for the surface shall not be less than 0.75mm.

Main Concrete Slab Properties:

- Flexural Strength at 28 days (for thickness design) - 4.5 MPa (approx. 40MPa concrete strength)
- Coefficient of Expansion (for joint design) - 10×10^6 per C°
- Coefficient of Drying Shrinkage (for joint design) - 600×10^6
- If reinforcement is provided, the area ratio shall be 0.67 – 0.72%.



Pavement Design

Types of Joint in Rigid Pavement

Joints

There are many types of joints used in the construction of concrete pavements but they all control the movement of the pavement and the associated cracking and/or differential settlement. Understanding the use and function of the different types of joints is required in determining their placement.

Types of Joints

1. **Longitudinal Joints**
   Longitudinal joints are used to relieve warping stresses and are generally needed when slab widths exceed 5 meters. Widths up to and including 5 meters have performed satisfactorily without a longitudinal joint, although there is the possibility of some longitudinal cracking. Longitudinal joints should coincide with pavement lane lines whenever possible, to improve traffic operations.

2. **Transverse Contraction Joints**
   The primary purpose of transverse contraction joints is to control the cracking that results from the tensile and bending stresses in concrete slabs caused by the cement hydration process, traffic loadings, and the environment.

3. **Transverse Construction Joints**
   Transverse construction joints shall be installed at the end of each day's placing operations, and when concrete pavement is interrupted for more than 30 minutes, or when it appears that the concrete will obtain its initial set before fresh concrete arrives.

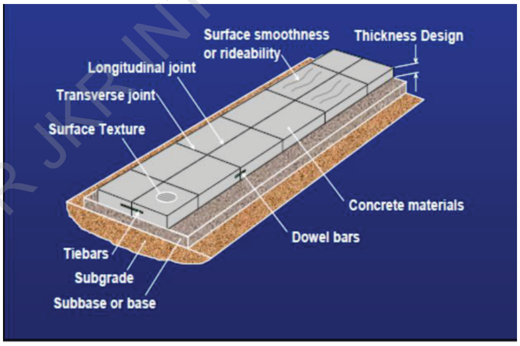


Figure N6: Typical joints in concrete road pavement

Figure N7: Concrete road pavement under construction

Pavement Design

Specialty Mixes and Surface Treatments

Cold-In-Place Recycling is a structural pavement rehabilitation technique that reuses the existing pavement materials by scarifying (200 – 500mm depth), stabilising (using bitumen emulsion, foamed bitumen, lime, Portland cement or fly ash) and relaying the recycled materials without heating. Finally, laid with a surface wearing course. Applicable to structurally deficient pavement usually associated with fatigue cracking, transverse thermal cracking and reflective cracking.

Figure N8: Cold-In-Place Recycling

Hot-In-Place Recycling is pavement rehabilitation technique used to address functional pavement distresses such as bleeding, ravelling, surface cracking and undulation. It involved heating, scarifying, blending (with fresh bituminous mix, rejuvenating agent and virgin bitumen), levelling and compacting the existing bituminous layers (max. 60mm).

Figure N9: Hot-In-Place Recycling

Porous Asphalt is a special purpose wearing course (non- structural) with open-graded aggregate mixed with polymer modified binder and contain high air voids (20 – 25%) for drainability (50mm minimum thickness). Exhibit less noise, better skid resistance, and reduce splash and hydroplaning.

Figure N10: Porous Asphalt

Polymer Modified Asphalt is a mixture of continuously graded aggregate and polymer modified binder (using PG 76 or higher mixed with polymer that produced the specified properties of the resulted binder and asphaltic concrete mix). This mix increases the resistance to rutting, fatigue cracking and improves adhesion of binder to aggregates.

Gap Graded Asphalt is a wearing course containing polymer modified bitumen and 100% crushed aggregates. Better stone to stone contact that enhance stiffness with improved mix stability with high content of polymer modified bitumen. It is suitable to solve cracking and deformation problem and offer increase durability, strength and texture depth (0.8-1.2mm).

Pavement Design

Specialty Mixes and Surface Treatments

Stone Mastic Asphalt is a dense gap graded hot mixed asphalt with large proportion of coarse aggregates (> 65%) and rich bitumen filler mastic (5.5 – 7.5% of polymer modified bitumen + cellulose fibres) filling in the voids. It provides durable surfacing, improved texture depth (0.7 – 1.0mm) and exhibit high resistance to rutting due to heavy axle loads.

Stone Mastic Asphalt **Conventional Asphalt**

Figure N11: Differential of coarse aggregates proportion between SMA and Conventional Asphalt

Surface Treatments

Chip Seal is an application of a binder (an emulsion or bitumen) onto a functional distressed pavement surface (such as bleeding, polishing, ravelling etc) followed by an application of single-size aggregate. Prior to the application, the existing surfacing has to be prepared by patching and filling the cracks with binder. The final operation is several passes of pneumatic tyre roller. Chip Seal is used to restore skid resistance, provide water proofing layer and retard binder hardening.

Figure N12: Differential of surface finishing between Chip Seal and Conventional Asphalt

Micro-Surfacing is a modified version of slurry seal consisting of a proportional mixture of polymer modified bitumen emulsion, selected mineral aggregate, mineral filler, water and other additives such as cement and latex. It is used to restore the surface characteristics of pavement or to preserve pavement surfacing. It can be used to correct rutting, improve skid resistance, seal surface cracks, protect pavement surfacing against hardening, and improve surface texturing.

Figure N13: Crack Sealing

Crack sealing is a preventive road maintenance technique whereby the cracks in the road surface are sealed to prevent water from infiltrating into the underlying pavement layers which can cause early failure of the pavement. It is not recommended for crocodile cracks or high density multiple cracks and other cracks which are due to structural damage.

Pavement Design

Pavement Evaluation

Introduction

Pavement Evaluation is a process in which systematic assessment of pavement condition is carried out to determine its modes of distress/ deterioration and then propose appropriate treatment/ rehabilitation design.

Pavement evaluation is needed to understand the behavior and performance of road pavement under a given condition. From pavement evaluation, the appropriate maintenance method can be obtained and suited to budget requirements.

Objective of Pavement Evaluation

1. To divide pavements into distinct lengths requiring different rehabilitation measures.
2. To determine the most suitable/ economical rehabilitation measure for each distinct length.

Pavement Evaluation Process

Pavement evaluation process can be summarized as follows:
1. To divide the road into suitable lengths of design sections.
2. Predict the failure mode.
3. Identify failure causes and delimit the failure area.
4. Select suitable short or long term remedial solutions.

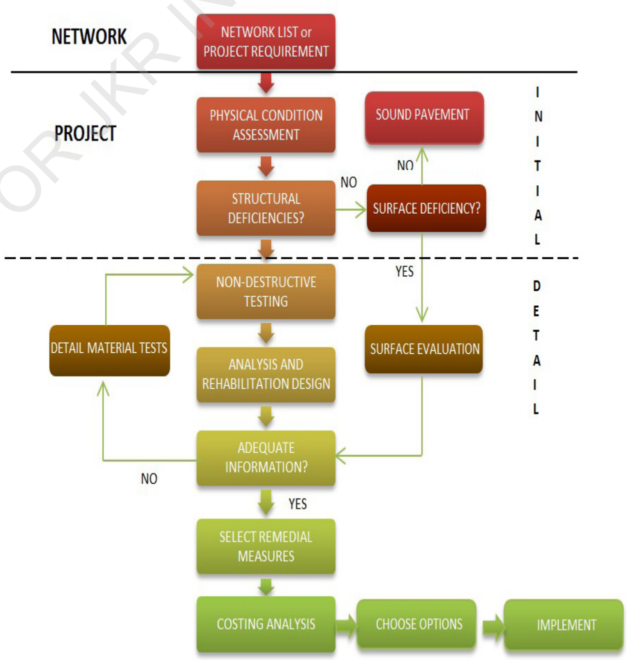


Figure N14: Flow Chart of Pavement Evaluation Process

Pavement Design

Pavement Evaluation

Pavement Deterioration

Pavement deterioration can be classified into two main types:

1. Structural Deterioration
2. Functional Deterioration

Structural deterioration takes place when one or more of the pavement layers have deteriorated to a level where it could not perform its function. Normally, structural deterioration manifest on the pavement surface by cracking, rutting and shoving.

Functional deterioration may or may not be accompanied by structural distress. It is normally indicated by defects such as roughness, ravelling, spalling and smooth pavement surface. The pavement may become sufficient rough and will not carry out its intended function without causing discomfort to road users.

Analysis in Pavement Evaluation

When the data collection have been finished, analysis is carried out to determine the pavement deterioration. The data which have been analysed can be summarized and presented in the form of Condition Stripmap as in Figure 1.

From that condition stripmap, the road length can be divided into various segments with the proposed rehabilitation options.

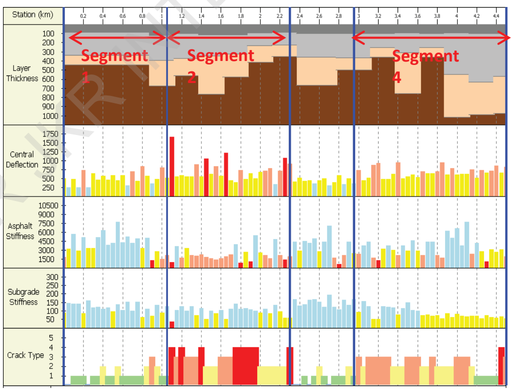


Figure N15: Condition Stripmap

Rehabilitation Options

When the pavement deteriorates, it has to be rehabilitated to maintain its serviceability standard. The type of rehabilitation required depends on the type and severity of distress the pavement is experiencing.

The rehabilitation of flexible pavements encompasses a broad range of activities which could be grouped into three categories namely:

1. Restoration
2. Resurfacing (structural)
3. Reconstruction

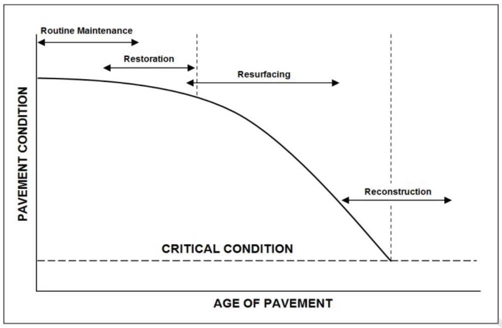


Figure N16: The Spectrum of Pavement Rehabilitation Alternatives

Restoration

As the pavement condition deteriorates further. Particularly when distress such as cracking and polishing of the aggregate become apparent, the restoration rehabilitation option is warranted.

Successful restoration work achieves one or more of the following; it repairs the existing distress, decreases the rate of increase of roughness, and slows down the subsequent pavement deterioration by arresting the mechanism causing the distress.

Resurfacing

When the pavement has suffered severe and extensive structural damage, restoration works may not be cost-effective. Structural improvement would then become a cost-effective option. It is therefore important to determine when a pavement requires structural improvements as opposed to restorative work.

Resurfacing is the most popular method of rehabilitating distressed pavements in Malaysia. It involves the placement of fresh material on the existing surfacing which improves riding quality and provides additional structural strength. It is necessary to design the overlay thickness in order to achieve the desired design life.

Reconstruction

Reconstruction of the pavement layers will be necessary when any of the layers has deteriorated beyond economical repair. Depending on the layers needing repair, reconstruction can be categorised into full or partial reconstruction.

Full reconstruction is needed when the existing subgrade has deteriorated and become unstable. Partial reconstruction is carried out when only the road base or the sub-base layers have deteriorated.

In order to determine the extent of reconstruction required, the pavement structure will have to be examined by carrying out an evaluation of the existing pavement condition. This can be done using non-destructive methods or by digging trial pits to carry out a more direct examination of the conditions of the lower pavement layers.

When the failure of the road base is very extensive, the road base can be recycled along with asphalt surfacing either by adding additional aggregate or cement to stabilise the new road base material.

The construction of recycled stabilised road bases requires specialised machinery. Standard plant are not suitable for this type of construction.

TRAFFIC SIGNS AND MARKINGS

Traffic Signs and Markings

About Road Traffic Signs

Traffic signs are very important for travellers and drivers alike. Erected at conspicuous places along roads, traffic signs provide useful information to road users. It also helps prevent road accidents and reduce risks when driving.

According to the *Arahan Teknik Jalan 2E/87* (*Pindaan 2011*): Guide signs Design and Application, traffic signs have five categories:

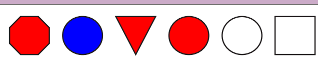
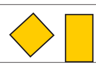
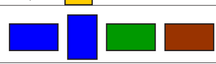
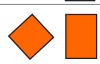
1. Regulatory signs,
2. Warning signs,
3. Temporary signs,
4. Guide signs, and
5. Other traffic signs.

There are three basic types of traffic sign. Signs which give orders, signs that warn and signs which give information. Each type has a different shape. A further guide to the function of a sign is its colour. There are a few exceptions to the shape and colour rules to give prominence to certain signs (e.g. the octagonal stop sign).

The following colours have been assigned with significant meanings to it:

- **White** : regulation;
- **Yellow**: warning.
- **Orange**: temporary traffic control;
- **Green**: indicated movements permitted, direction guidance;
- **Red**: stop or prohibition;
- **Blue**: road user services guidance, tourist information, and evacuation route;
- **Brown**: recreational and cultural interest area guidance;
- **Fluorescent Yellow - Green**: pedestrian warning, bicycle warning, playground warning, school bus and school warning;
- **Fluorescent Yellow**
- **Fluorescent Orange**

Table H1: Symbol, Colour and Shape of Traffic Sign

Type of Sign	Symbol	Standard Color and Shape
Regulatory	RP or RM	
Warning	WD	
Guide	G	
Temporary	T	

Traffic Signs and Markings

Classification and Design of Traffic Signs

Classification of Traffic Signs

There are a few different classifications of signs. These classifications help us to make more sense of the signs by grouping them into more general stratifications.

Functionally, traffic signs are generally classified into the following types :

1. Regulatory
    - Regulatory Prohibitive Signs - designated as RP
    - Regulatory Mandatory Signs - designated as RM
2. Warning Danger Signs - designated as WD
3. Temporary/Roadwork Signs - designated as T
4. Guide Signs - designated as G
    - Destination Signs
    - Directional Signs
        - » Advance Direction Signs
        - » Intersection Direction Signs
        - » Re-assurance (confirmatory) Signs
    - Distance Signs
    - Information Signs
        - » General Services Signs
        - » Recreational/Historical/Cultural Interest Area Signs
        - » Major Housing Estates
        - » River Name Signs
        - » Town/Village Names
        - » Government Building Signs
        - » Government Related Premises
            - – Route Number Markers
            - – Kilometre Posts
5. Other Information and Traffic Instruction Signs

– Gantry Sign

Design of Traffic Signs

The shape an colour of all signs for normal use have been standardised under Arahan Teknik Jalan (ATJ) and legalised under the Road Traffic Rules.

For most standard signs, ATJ specifies a range of sizes. In general, the smallest size should normally be used when the following conditions are complied:

1. The 85^{th} percentile approach speed is less than 70 km/h.
2. The target value of the sign is not affected by the background or surrounding objects.
3. The sign is reasonably close to the road user's path and within normal sight.

Progressively larger signs can be adopted if the above conditions are not fulfilled. The larger signs are used only where justified, because their excessive use in normal situations simply reduces its effectiveness in unusual circumstances.

Traffic Signs and Markings

Effective Traffic Signs

Effective Traffic Signs

What makes an Effective Traffic Signs?

For a sign to be effective, it should be:

- the sign should be conspicuous so that they will attract the attention of drivers at a sufficient distance and should be easily recognizable as traffic signs at that distance
- the signs should contain only essential information and their significance should be clear at a glance so that the driver's attention is not distracted from he task of driving
- the signs should be legible from sufficiently far away to be read without diverting the sight through too great an angle
- the signs should be placed so that they are obscured as little as possible by vehicles and other objects
- the signs should be designed so that the driver is left with
- sufficient time to take any necessary action safely
- the signs should be effective both by night and day. The critical factors in meeting these requirement are colour, shape and size of sign, lettering and symbol sizes used, layout of its face, its position and illumination or reflectorization

The followings are some of the basic requirements for the installation of traffic signs:

- Provision of minimum number (3 no. major; 2 no. minor) of advance destination sign.
- Signs should be located min 3.6 m away from the edge of the traveled way.
- Height of Signs should be:
  - 1.5 m (rural),
  - 1.8 m (warning sign in urban area),
  - 2.2 m(destination sign in urban area)
- Must be positioned appropriately, visible, legible and correct size
- Not more than 5 information to be conveyed on a sign
- The more serious the hazard the bigger the sign
- Lower case letters are easier to read
- Destination Signs
  - The sign should be located at a distance of 1km and 500 m in advance of the turning roadway or junction
- Directional Signs
- Two types of signage
  - Stack Type
  - Map Type
- Distance Signs
  - Should be located at the following location
    - 200 m from a turning roadway or 150 m beyond an acceleration lane
    - 100 m outside the city or municipality limits or at the edge of the built-up districts
    - 20 km intervals along the route, if there is no junction

Traffic Signs and Markings

Effective Traffic Signs

- Route Names
  - The route name to be displayed on the distance sign shall have been gazetted
-
- Route Number Markers
  - On State roads, the route number markers should be initiated with the same alphabet designated on car registration numbers which has already been assigned for that particular state
  - Route number marker type B shall be located at the following location of minor road or where destination sign are not applicable:
    - ◊ Distance 200 m from a turning roadway or 150 m beyond an acceleration lane.
    - ◊ 20 km intervals along the route if there are no junctions

- Information Signs
  - Can be in a form of either symbols or word messages and shall be erected according to the nature of the information to be given

Traffic Signs and Markings

Shapes and Sizes of Traffic Signs

Shapes and Sizes of Traffic Sign

a) Circular
- Size when used with traffic signal: diameter = 300 mm
- Minimum size: diameter = 600 mm
- Normal size: diameter = 750 mm

b) Octagonal
- Minimum size : Width = 600 mm.
- Other size : Width = 900 mm

c) Triangular (Equilateral)
- Minimum size ; Width = 600 mm
- Normal size : Width = 750 mm

d) Diamond (square with vertical diagonal)
- Minimum size : Width = 400 mm
- Normal size : Width = 600 mm
- Other size : Width = 750 mm

e) Rectangular
- Size varies according to legend (word message/symbol) on sign

Table H2: Letter Size of principal word message on Guide Signs

Type of Road	Min Letter Size
Expressways and major highways	at least 200 mm
Road in rural districts	at least 150 mm
Rural roads and urban streets	at least 100 mm

Letter Size

The size of lettering used must be such as to be legible at distance that will give road users sufficient time to read the sign before passing it. Conceptually, any letter can be seen at a distance approximately about 7m per 10mm of letter height.

However, the suitable letter height can be calculated using the following formula:

$$\textbf{Letter height} = \frac{\mathbf{2tV + 5.7s}}{\mathbf{0.04d}} \textbf{ (mm)}$$

where

t = time required for a simple glance (1.5 seconds for a simple sign)

v = vehicle speed (m/sec)

s = distance from the center of sign to the line of travel of the road user (6.6m for signs less than 6m long)

d = distance in meter at which 25mm letters can be read (use d = 15m)

Table H3: Letter Size based on Speed and Roadway Type

Speed Limit	Letter Height	
	Single Carr.	Multiple Carr.
> 90 km/h	400	400
80 - 90	250	300
60 - 80	200	250
< 60 km/h	150	200

Traffic Signs and Markings

Colour of Traffic Signs

Table H4: Colour of Traffic Signs

	TYPES OF TRAFFIC SIGNS	LETTERING / SYMBOL & BORDER	BACKGROUND	REMARK
I	REGULATORY SIGNS	As shown in Arahan Teknik (Jalan) 2A/85		
II	WARNING SIGNS	As shown in Arahan Teknik (Jalan) 2A/85		
III	TEMPORARY SIGNS	As shown in Arahan Teknik (Jalan) 2C/85		
IV	GUIDE SIGNS			
	a. Destination Signs	White	Blue	Except on LLM expressways which should be white letters / border on green background
	b. Directional Signs	White	Blue	Those leading to roads within local council i.e. local streets should have yellow letters for street name.
		White	Green	Those leading to or/and on LLM Expressways.
	c. Distance Signs	White	Blue	Except on LLM expressways (white on green)
	d. Information Signs			
	i. General Services	White	Blue	
	ii. Recreational / Historical & Cultural Interest Areas	White	Brown	
	iii. Major Housing Estates	Blue	White	
	iv. River Name	Green	White	
	v. Town / Village Name	**Black**	White	
	vi. Government Building	Yellow	Green	
	vii. Government Related Premises	Green	White	
	e. Route Number Markers	Black	Fluorescent Yellow	
	f. Kilometre Posts	As shown in Arahan Teknik (Jalan) 9/86		
V	OTHER TRAFFIC SIGNS a. Gantry Signs	White	Blue	Applies to all roads except LLM expressways. Local streets should have yellow letters for the street name.

Traffic Signs and Markings

Clearance and Placement of Traffic Signs

Vertical Clearance

- Rural areas :a $\geq$ 1.5 m
- Business & Residential areas : a $\geq$ 2.2m
- Divided Highways : a $\geq$ 1.8 m
- For destination signs: a $\geq$ 2.2 m
- Overhead signs should be at least 5.4 m minimum above pavement

Lateral Clearance

- With road shoulders: b > 0.6m
- Without road shoulders: b > 3.6m
- Outside kerb face, guardrail line, paved shoulder : b > 0.6m
- Sign should be oriented at approximately right angle to, and facing, approaching traffic
- To avoid mirror-like reflection, signs should be at an angle of about 3 - 5 degrees away from the normal (about 93 degrees from direction of traffic)

Longitudinal Placement

Warning or guide signs should be located sufficiently in advance of the potential hazard or decision point to enable users to see and read them and to take the necessary action. The details are shown on the following pages.

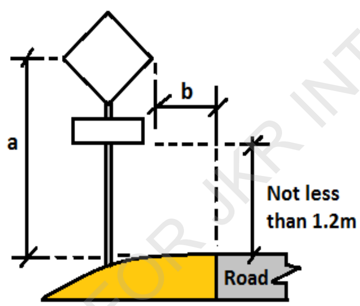


Figure H1: Placement of Traffic Sign

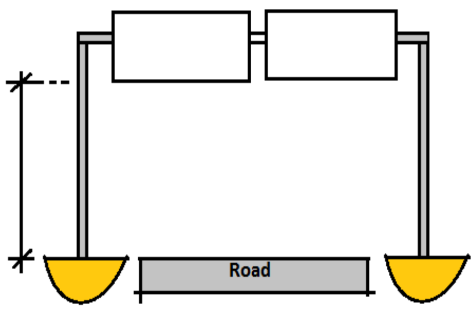


Figure H2: Vertical Clearance of Gantry Sign

Traffic Signs and Markings

Distance, Destination and Directional Signs

TYPICAL APPLICATION OF GUIDE SIGNS FOR T-JUNCTION NOT LEADING TO PLACE NAMES BUT MAJOR STATE ROADS

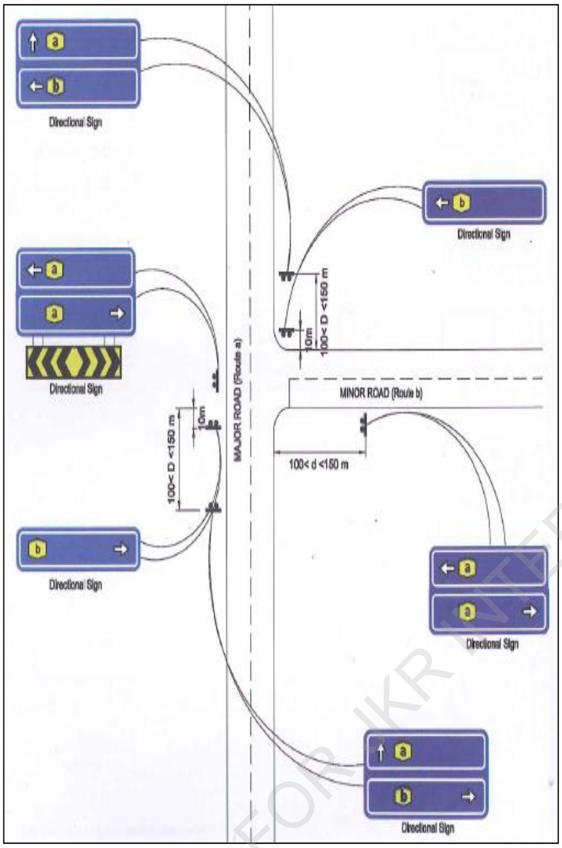


Figure H3: Guide Signs For T-Junction

TYPICAL APPLICATION OF GUIDE SIGNS FOR CROSS INTERSECTION NOT LEADING TO PLACE NAMES BUT MAJOR STATE ROADS

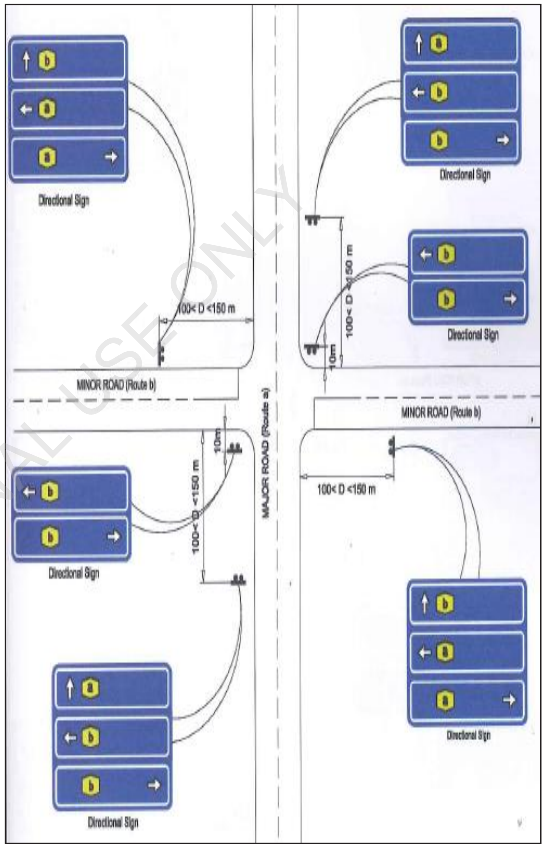


Figure H4: Guide Signs For Cross Intersection

Traffic Signs and Markings

Road Markings

Road or pavement markings must be present on any paved road to regulate traffic, warn or guide road users. They either may be used alone or to supplement other traffic control devices.

All road markings, like other traffic control devices should be uniform in design, position and application so that they may be recognized and understood immediately by all road users. Road markings may consist of the following items:

- Longitudinal lines
- Transverse lines
- Other marking

A summary of the dimensions of longitudinal lines for rural and urban roads is as shown below (Table H4).

However, transverse lines should be wider than longitudinal lines due to the low angle of view. They shall be of non-skid material and thickness of not more than 3mm (between 3 - 7 mm).

Typical width of transverse lines:

- Stop line - at least 300 mm wide
- Holding lines or give way lines - at least 200 mm wide
- Parking lane line - 100 - 150 mm wide
- Yellow Transverse bar - 600 mm wide

Problems arising with the use of road markings:

- Subject to traffic wear, it hence requires frequent maintenance.
- Effectiveness on wet roads at night and during heavy monsoon rain depends on the service life.
- Large painted areas of pavements can cause skidding problems.
- Visibility distance can be greatly reduced by crest vertical curves.
- Transverse and word/symbol markings must be elongated to be easily seen and read by drivers.
- Messages may be hidden by vehicles stopped over the markings.

Table H5 : Summary of the Dimensions of Road Markings

Design Standard	Element	Broken Line			Unbroken Line		
		Centre Line	Lane Line	Continuity Line	Edge Line	No Passing Zone Line	Lane Line
R6	Width	N.A	0.15	0.20			
	Length	N.A	4.50	3.00	0.2	N.A	N.A
	Gap	N.A	7.50	3.00			
R5, R4 & R3	Width	0.10	0.10	0.20			
	Length	4.50	4.50	1.00	0.15	0.1	0.1
	Gap	7.50	7.50	1.00			
U6	Width	N.A	0.15	0.20			
	Length	N.A	4.50	3.00	0.20	N.A	N.A
	Gap	N.A	7.50	3.00			
U5, U4, U3, U2 & U1	Width	0.10	0.10	0.10			
	Length	4.00	1.80	1.00	0.10	0.1	0.1
	Gap	2.00	3.00	1.00			

ROAD LIGHTING

Road Lighting

Introduction to Road Lighting

Road lighting is an integral part of road infrastructure that provides the road environment, in particular hazardous objects, with sufficient visibility to the road users. This would enhance traffic flow, improve comfort and creates safer road environment.

When planning for the provision of road lighting, the following requirements shall be taken into consideration:

- driver's requirements
- vulnerable road user's requirements
- lighting for surrounding
- environmental considerations

Malaysia Standard on Road Lighting MS825 provides different list and definition of road categories from that given by Arahan Teknik Jalan. The table above shows the equivalent definition of MS 825 with that of the Arahan Teknik Jalan. This is to avoid any ambiguity and confusion especially when it involves construction and installation contractual matters.

General Classification of Roads - equivalent definition by MS825 & Arahan Teknik Jalan

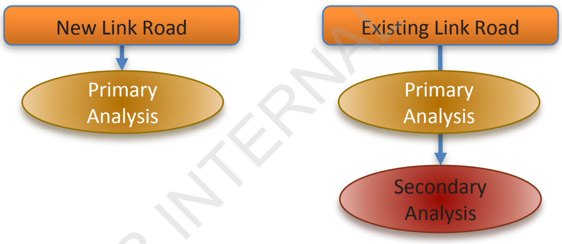
MS 825	ATJ Rural	ATJ Urban
Highway	Expressway	Expressway
Strategic	Highway	Arterial Roads - Protocol, Major and Strategic Roads
Main Distributor	Primary Road	Collector Roads
Secondary Distributor	Secondary Road	Local Roads - include service roads and residential roads
Link Roads	Minor Road	

Road Lighting

Need for Road Lighting

Understanding the functions and capacities of each category of road should form the basis in determining the lighting need and level of lighting necessary particularly when dealing with midblock sections of a road. Installation of lighting for some roads shall be automatically approved due to their economic role and imperative national strategy. Others may have to go through the criteria evaluation process before any decision is made on the installation of road lighting. The need for road lighting can be divided into 2 (two) basic locations, i.e. midblock section and intersection.

Midblock Lighting



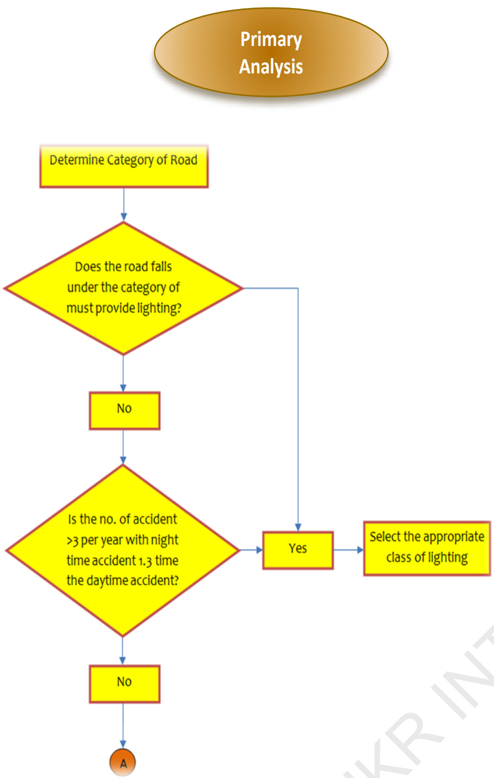
The warrant for lighting of the midblock section shall be based on the output of the primary and/or secondary analysis. The flowchart below shows the analysis that need to be performed depending on the type of link road under consideration. While the warrant for lighting of the intersection depends on the types of intersection road.

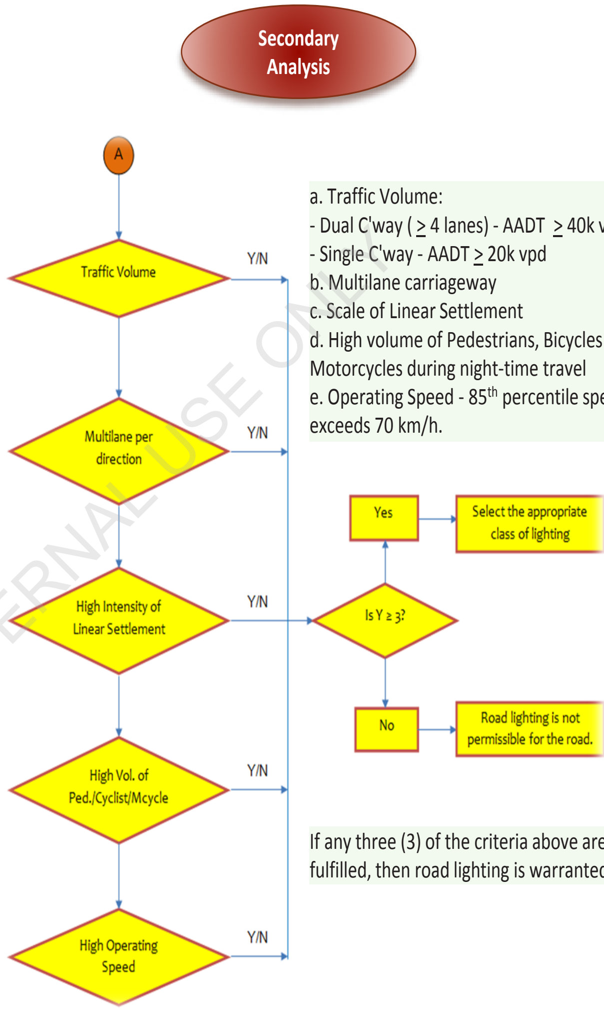
Intersection Lighting

The installation of road lighting for intersection shall be based on the category of the intersecting roads. The need for lighting is specified in the subsequent page.

Road Lighting

Warrant Analysis for Lighting of Midblock





a. Traffic Volume:
- Dual C'way ($\geq$ 4 lanes) - AADT $\geq$ 40k vpd
- Single C'way - AADT $\geq$ 20k vpd

b. Multilane carriageway
c. Scale of Linear Settlement
d. High volume of Pedestrians, Bicycles and Motorcycles during night-time travel
e. Operating Speed - 85th percentile speed exceeds 70 km/h.

If any three (3) of the criteria above are fulfilled, then road lighting is warranted.

Road Lighting

Warrant Analysis for Lighting of Intersection

INTERSECTING ROADS IN RURAL AREA

Expressway	Highway	Primary	Secondary	Local	
IC (Y)	IC (Y)	IC (Y)	-	-	**Expressway**
	IC (Y)	IC / SI (Y)	SI / SC (Y)	SC (Optional)	**Highway**
		SI (Y)	SI / SC (Y)	SC (Optional)	**Primary**
			SC (Optional)	SC (Optional)	**Secondary**
				SC (optional)	**Local**

Intersecting Roads in Urban Area

Expressway	Arterial	Collector	Local Street	
IC (Y)	IC (Y)	-	-	**Expressway**
	IC / SI (Y)	SI (Y)	SI / SC (Y)	**Arterial**
		SI (Y)	SC (Optional)	**Collector**
			SC (Optional)	**Local Street**

Note:
Intersection lighting is also warranted based on accident rate. Night-to-day accident rate shall be greater than 1.3.

IC – Interchange; SI – Signalised Intersection; SC – Stop Control
(Y) – Yes for Lighting; (N) – No for Lighting; (Optional)

Road Lighting

Lighting Classes by Classification of Roads

Recommended Lighting Classes for Rural and Urban roads

Rural Road	Lighting Class	Urban Road
Expressway	ME1	Expressway
Highway	ME1	Arterial
Primary Road	ME2	Collector
Secondary Road	ME3a / 2	Local
Minor	ME5 / 4b	Local

Road Hierarchy Equivalent with Recommended Lighting Classes.

MS825	Lighting Class	REAM / ATJ
Highway	ME 1	Expressway
Strategic route	ME 1	Highway
Main distributor	ME 2	Primary road
Secondary Distributor	ME 3a / 2	Secondary road
Link road	ME 5 / 4b	minor road

Note:
The lighting classes are as defined in MS 825.

Road Lighting

Lighting for Other Facilities

Facilities where road lighting is made as a mandatory requirement:

- Pedestrian Crossings
- Bridges and Elevated Structures - Installation can shall be considered for the following cases:
  - Approach to bridges
  - For curved bridges less than 100 m span
  - Bridges with more than 100 m span.
- Tunnels / Underpasses

Lighting Classes of Comparable Levels (BS EN 13201-2)

ME Class (for traffic routes)	CE Class (for conflict areas)	S Class (for footways, cycleways, emergency lanes)
-	CE0	-
ME1	CE1	-
ME2	CE2	-
ME3	CE3	S1
ME4	CE4	S2
ME5	CE5	S3
ME6	-	S4
-	-	S5
-	-	S6

TRAFFIC IMPACT ASSESSMENT

Traffic Impact Assessment

Scope & Process of TIA

TIA is an important tool used to determined the impact of traffic generated from a proposed site development project (upon full development) on surrounding road and transportation systems. It identifies the need for mitigation measures for a transportation system to reduce congestion, as well as to maintain or improved road safety The general process in which TIA is involved in application for Planning Permission is depicted in figure below :

Analysis of impacts of projected generated traffic in area of study Trip forecasting with sequential steps of trip generation, trip distribution and trip assignment Information on land use and development in surrounding area of project

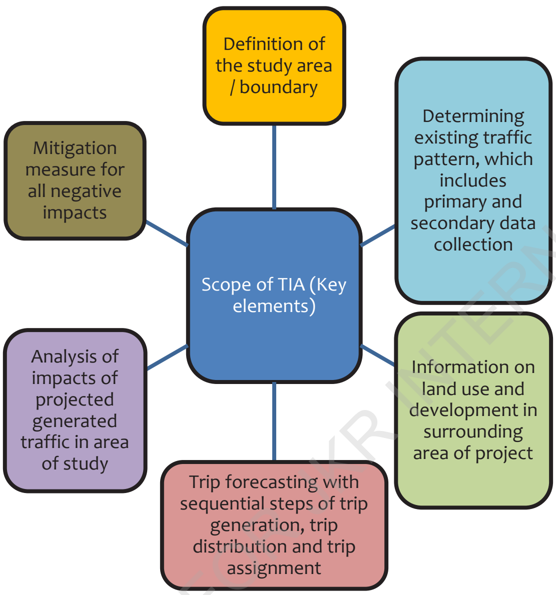


Figure J1

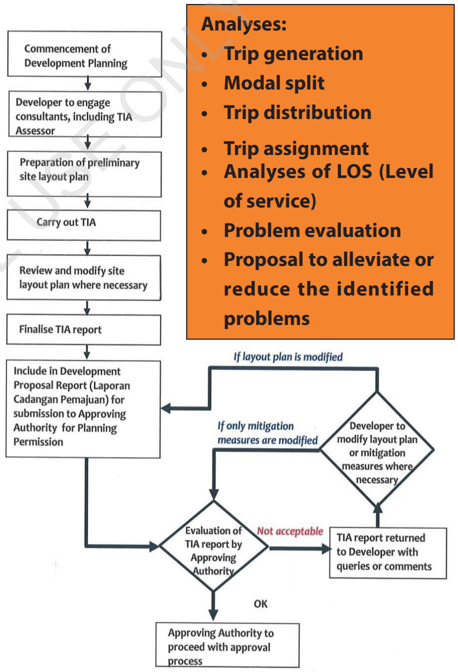


Figure J2

TIA should start at the early planning stages of a project, including site selection stage. Early participation of TIA Assessor will contribute towards the preparation of a more responsive and cost- effective site plan.

Traffic Impact Assessment

Criteria, Trigger Levels & LOS

CRITERIA AND TRIGGER LEVELS

It is necessary to know when a traffic impact assessment is required. This is because not all developments will cause significant impact on their surroundings, especially those in the rural areas. Generally, the criteria for warranting a TIA are as follows :

- When a development generates a specified number of peak hour trips;
- When a development generates a specified number of daily trips;
- When a development contains a specified number of dwelling units or specified built-up area;
- When a development occurs in a sensitive area or;
- When the Appropriate Authority considers it necessary under unusual situation
- All 4 criteria must be tested, and if **any one** of the criteria reaches the trigger level, TIA is required.

The table below shows the criteria and corresponding trigger levels for warranting TIA shall be :

LEVEL OF SERVICE (LOS)

The intersection performance indicator used is Level Of Service (LOS) which is based on the delay of particular movement. Hence, delay is defined in terms of the average stopped time per vehicle traversing the intersection.

Table J2 : Level of Services

NO	CRITERIA	TRIGGER LEVELS
1	Peak Hour Generation (Commuter peak)	150 added vehicles per hour (2-way)
2	Off-Peak Hour Trip Generation (Generator peak occurs at the off- peak-period)	200 added vehicles per hour (2-way)
3	Size of residential development	200 dwelling units
4	Size of commercial development	45,000 sq.ft. (gross floor area)

Table J1 : Criteria and Corresponding Trigger Levels

LOS	Control Delay per Veh in seconds (d) (Including geometric delay)		Volume/ capacity, (v/c) ratio
	Signalised intersection	Stop & Give Way (Yield) intersection	
A	d ≤10	d≤10	v/c≤0.6
B	10<d≤20	10<d≤15	0.6<v/c≤0.7
C	20<d≤35	15<d≤25	0.7<v/c≤0.8
D	35<d≤55	25<d≤35	0.8<v/c≤0.9
E	55<d≤80	35<d≤50	0.9<v/c≤1.00
F	d>80	d>50	v/c>1.00

The steps required in TIA are generally as follows :

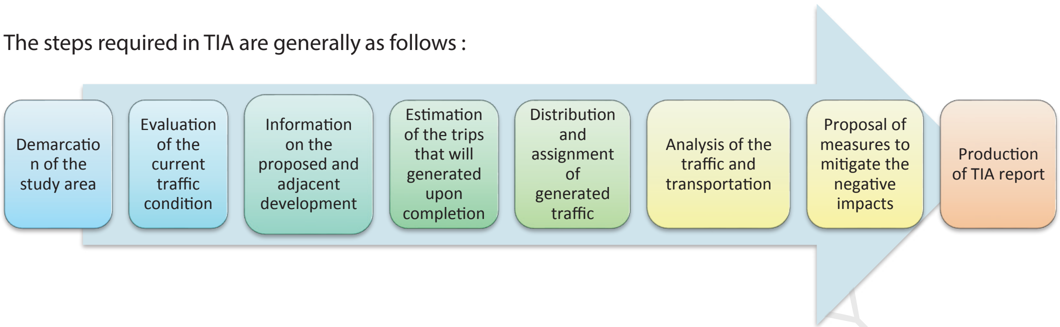


Figure J3: Steps Required for TIA

ANALYSIS OF THE CURRENT SITUATION OF THE STUDY AREA

To do the analysis we need to get the base-line situation data and the peak hours of travel activities in the study area.

BASE-LINE SITUATION

The analysis of the current situation of the study area is important as it will serve as the base-line situation for determining the impacts of the proposed development.

IDENTIFICATION OF THE PEAK HOURS

- The traffic impact will be study during the peak hours of travel activities
- A 16 hour (12 hour for less busy area) survey shall be carried out to identified the peak hours
- The survey should be conducted on a typical working weekday
- Additional survey on weekend only apply for proposed development with retail component having gross floor area of 100,000 sq ft or more
- Survey should not be conducted in irregular seasons when travel pattern is not normal (e.g during school holidays, major

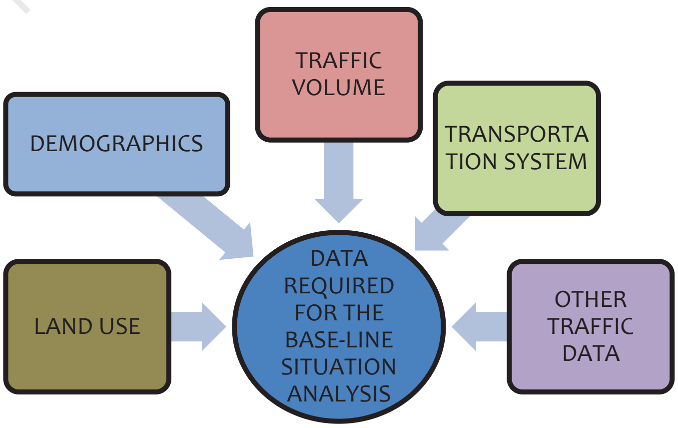


Figure J4: Data required for Baseline Analysis

Traffic Impact Assessment

Trip Generation

TRIP GENERATION (TG)

TG - the total number of INBOUND (trip attraction) and OUTBOUND (trip production) vehicle trips from a site over a given period. Reliable estimate of the increase in traffic trips that will be caused by the proposed development is one of the key parameters that will determine the quality of the TIA. Generally, there are two categories of increased trips: **NON-SITE TRAFFIC and SITE TRAFFIC.**

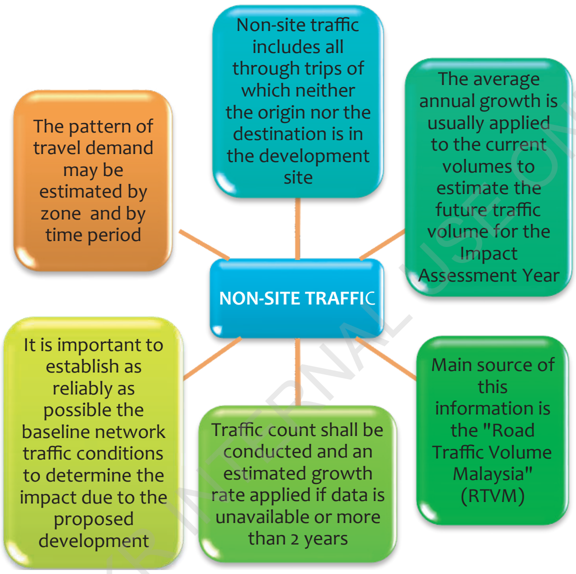


Figure J5 : Non Site Traffic - includes all through trips of which neither the origin nor the destination is in the development site

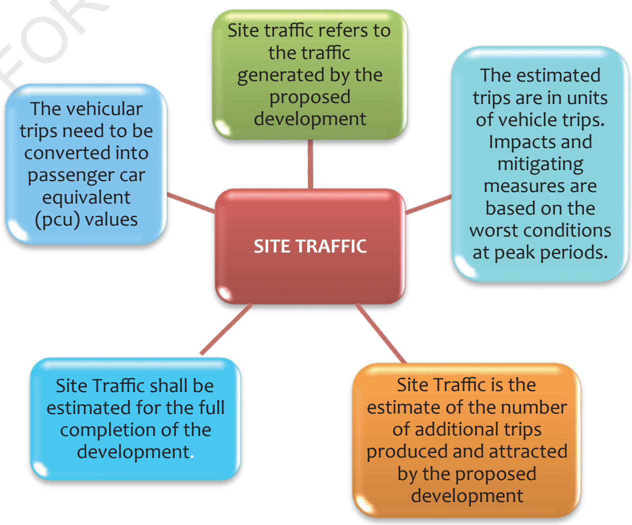


Figure J6: Site Traffic refers to the traffic generated by the proposed development.

PASSENGER CAR UNIT (PCU) CONVERSION FACTOR

The vehicular trips need to be converted into PCU before subsequent steps of trip distribution and trip assignment can proceed.

Table J3 : PCU Conversion Factor

Type of Vehicle	Equivalent Value in pcu			
	Rural Standard *	Urban Standard *	Round- About Design *	Traffic Signal Design **
Passenger Cars	1.00	1.00	1.00	1.00
Motor Cycles	1.00	0.75	0.75	0.22
Light Vans	2.00	2.00	2.00	1.00
Medium Lorries	2.50	2.50	2.80	1.19
Heavy Lorries	3.00	3.00	2.80	2.27
Buses	3.00	3.00	2.80	2.08

Reference :
** - Highway Capacity Manual Malaysia, HPU 2006*
*** - Highway Capacity Manual Malaysia, HPU 2011*

TRIP DISTRIBUTION

Trip distribution is a model of the number of trips that occur between each origin zone and each destination zone.

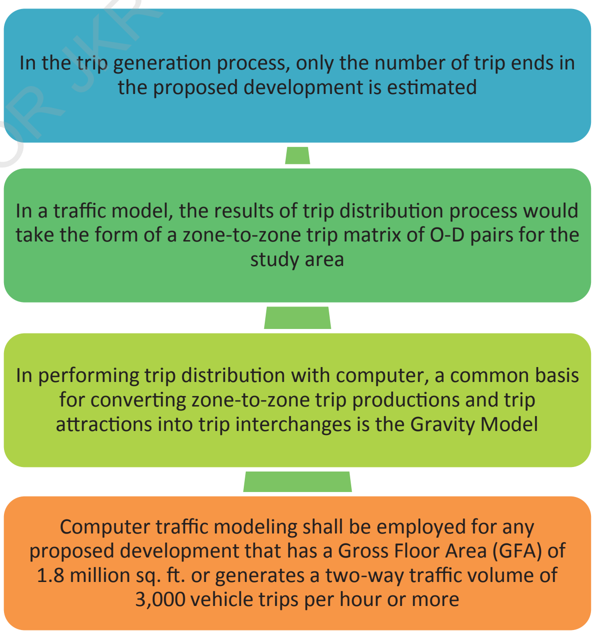


Figure J7: Trip Distribution

Traffic Impact Assessment

Trip Assignment

TRIP ASSIGNMENT

Trip assignment - to identify the routes or destinations taken by traffic to and from the development site.

At this stage, the total volume of trips produced by and attracted to the proposed development, and their directions of flow would have been determined

The generated trips are assigned to the road network in the study area

Trip assignment models are formulated to predict the number of trips using various routes and, hence the traffic on the links and intersections of a road network.

The assumption for most assignment or route choice models is that people will choose the route which offers the shortest travel time.

For the purpose of traffic impact analysis, modal split between private and public transport shall not be considered.

Figure J8: Trip Assignment

TRAFFIC IMPACT

The traffic impact caused by the proposed development is defined as the negative change in the Level of Service (LOS) indicated by the comparison of the Baseline Traffic Conditions in IAY against the Development Impacted Traffic Conditions in IAY.

the computation of LOS shall be based on the recommendations of the latest version the Highway Capacity Manual (HCM) Malaysia published by the Highway Planning Unit, Ministry of Works, Malaysia.

The traffic impact shall be examined at each and every one of the designated locations.

For each individual intersection, LOS of each lane group of all approaches shall be presented individually. Apart from the LOS, the respective degree of saturation (v/c ratios) as well as the maximum queue lengths shall also be computed

LOS of junctions and mid-block shall be analysed individually.

When a segment (the one-directional distance from one signalised intersection to the next) of a road is less than 300m, the adjacent junctions shall be analysed together

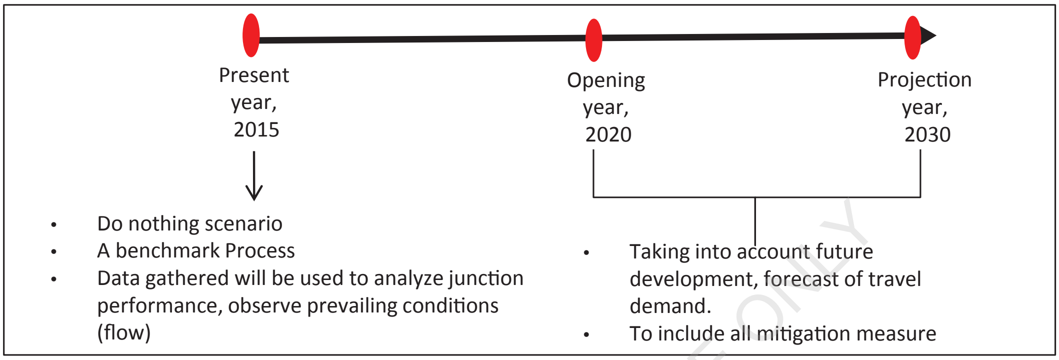
Figure J9: Traffic Impact

Traffic Impact Assessment

Projection Year

PROJECTION YEAR

The traffic impact analysis shall be projected up to 10 years after development is fully completed and operational.



TRAFFIC CONDITION TO BE ACHIEVED BY MITIGATION MEASURES

The minimum traffic condition to be achieved after mitigation measures are in place shall be as shown in the table below :

Table J4: Baseline and Minimum Traffic Conditions

Baseline Traffic Condition in IAY **	Minimum Traffic Condition (LOS) after Mitigation Measures ***
A	D
B	D
C	D
D	D
E	D (exception E)*
F	D (exception E)*

- *Where the Baseline Traffic Condition IAY is at LOS E, the target mitigated LOS shall also be D. However, where site condition is very restrictive and Approving Authority is convinced that the highest LOS achievable after mitigation measures is level E, the Approving Authority may consider allowing an exemption of the LOS D requirement*
- *Where Baseline Traffic Condition IAY is at LOS F, it indicates that the existing road network, or part of it, is already below acceptable operating condition. New traffic should not be allowed to enter the road network. In general, Approving Authority should not consider approving any new development that will cause negative traffic impact to the existing network unless the developer can demonstrate that he can, and undertakes to, upgrade the existing roads to achieve the requirement in the table above.*

** *IAY means Impact Analysis Year*

*** *These requirements are applicable to road segments and each element of the intersections individually.*

MITIGATION MEASURE

Where the analysis shows that there will be negative impact, mitigation measures must be proposed to upgrade the road facilities at that location.

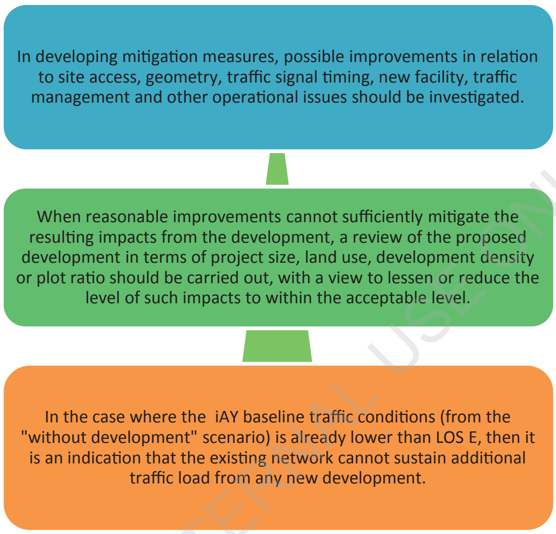


Figure J10: Mitigation Measures

TIA REPORT

The final TIA report shall contain the item listed below :

Figure J11: Content of TIA Report

VALIDITY PERIOD OF TIA STUDY

TIA Report is only valid for two (2) years after the date of TIA study.

DRAINAGE DESIGN

Drainage Design

Hydrology

Drainage System is designed to drain excess rain and ground water from impervious surfaces such as pavement, parking lots, and sidewalk. It is essential that adequate provision is made for road drainage to ensure that a road pavement performs satisfactorily. The main functions of a road drainage system are :

- **To prevent** flooding of the road and ponding on the road surface that can cause skidding car.
- **To protect** the bearing capacity of the pavement and the subgrade material from failure.
- **To avoid** the erosion of side slopes which can led to landslide.

The recommended recurrence interval for design are shown in **Table K1** and **Table K2** shows the recommended freeboard clearance for both bridge and culverts. The tables are applicable to both rural and urban areas.

Table K1 : Recommended Freeboard Level for Bridge and Culverts (ATJ 15/97)

Type of Structure	Freeboard Level (m)		
	U2 and below R2 and below	U3 - U4 R3 - R4	U5 - U6 R5 - R6
Bridges	1.0	1.0	1.0
Culverts	at formation level**		

**For high embankment when the water level at the inlet exceed 1.0m above the crown of culvert the designer must check stability of the whole embankment against the fluctuation of pore water pressure.

Description	Recurrence Interval in Years		
	U2 and below R2 and below	U3 - U4 R3 - R4	U5 - U6 R5 - R6
Bridges	50 25*	100 50*	100*
Culverts	20	25	50*
Road Surface Drainage	5	5	5
Interceptor Drain	25	25	25

Table K2 : Recommended Recurrence Interval for Design (ATJ15/97)

NOTES : * This recurrence interval can be used by the designer if one or any combination of the following condition applies:

a) If the structure is located in a flood plain

b) If the structure requires a high embankment

c) Poor soil condition making high embankment uneconomical

Under the above conditions, the structure must be designed as submersible structure. Special consideration however must be given against accumulation of debris or impact by logs etc.

Drainage Design

Hydrological Design Procedure

Design Procedure for estimating a peak flow, Q for a particular ARI using Rational Method.

1. Select Design ARI for drainage system
2. Divide sub-catchment into segments of homogeneous landuse or surface slope.
3. Using Equation from **Table K3** to estimate time of concentration, t_c
4. Determine average rainfall intensity, *i* for design ARI from IDF (Intensity-Duration-Frequency) data for area of interest.
5. Estimate runoff coefficients, C from **Table K4** to calculate average runoff coefficient.
6. Calculate peak flow rate, Q for the sub-catchment.

Table K3 : Equations to Estimate Time of Concentration (MSMA, 2012)

Travel Path	Travel Time	Remark
Overland Flow	$t_o = \frac{107.n^*.L^{1/3}}{S^{1/5}}$	t_o = Overland sheet flow travel time (minutes) L = Overland sheet flow path length (m) *for Steep Slope (>10%), L ≤ 50 m* *for Moderate Slope (<5%), L ≤ 100 m* *for Mild Slope (<1%), L ≤ 200 m* n^* = Horton's roughness value for the surface (Table 2.2) S = Slope of overland surface (%)
Curb Gutter Flow	$t_g = \frac{L}{40\sqrt{S}}$	t_g = Curb gutter flow time (minutes) L = Length of curb gutter flow (m) S = Longitudinal slope of the curb gutter (%)
Drain Flow	$t_d = \frac{n.L}{60R^{2/3}S^{1/2}}$	n = Manning's roughness coefficient (Table 2.3) R = Hydraulic radius (m) S = Friction slope (m/m) L = Length of reach (m) t_d = Travel time in the drain (minutes)

Table K4 : Recommended Runoff Coefficient for Various Land Uses (MSMA, 2012)

Landuse	Runoff Coefficient (C)	
	For Minor System (≤10 year ARI)	For Major System (> 10 year ARI)
Residential		
Bungalow	0.65	0.70
Semi-detached Bungalow	0.70	0.75
Link and Terrace House	0.80	0.90
Flat and Apartment	0.80	0.85
Condominium	0.75	0.80
Commercial and Business Centres	0.90	0.95
Industrial	0.90	0.95
Sport Fields, Park and Agriculture	0.30	0.40
Open Spaces		
Bare Soil (No Cover)	0.50	0.60
Grass Cover	0.40	0.50
Bush Cover	0.35	0.45
Forest Cover	0.30	0.40
Roads and Highways	0.95	0.95
Water Body (Pond)		
Detention Pond (with outlet)	0.95	0.95
Retention Pond (no outlet)	0.00	0.00

Note: The runoff coefficients in this table are given as a guide for designers. The near-field runoff coefficient for any single or mixed landuse should be determined based on the imperviousness of the area.

NOTES : The runoff coefficients in this table are given as a guide for designers. The near-field runoff coefficient for any single or mixed landuse should be determined based on the imperviousness of the area.

Drainage Design

Surface Drainage

Surface Drainage

One of the most important aspect of the location and design of rural highways and city streets is the necessity for providing adequate drainage. Adequate and economical drainage is absolutely essential for the protection of the investment made in a highway structure and for safe- guarding the lives of the persons who use it.

The major cause of pavement failure in highways is water. It has been appreciated since roads were first built that their stability can only be maintained if the surface and foundation remain in a relatively dry condition. Water brings about pavement failures within highways by hydraulic forces within pavement surfacing, softening the road surface when it is constructed of soil or sand-clay or gravel or water bound macadam, washing out unprotected areas of the top surface, erosion of side slopes forming gullies, erosion of side drains and softening the subgrade soil and decreasing its bearing capacity.

The function of surface drainage is to remove excess water brought about by rainfall. Surface drainage systems in built-up areas are generally connected to other drainage systems such as storm sewers, lakes or rivers while that in rural areas are connected to natural drainage channels or watercourses.

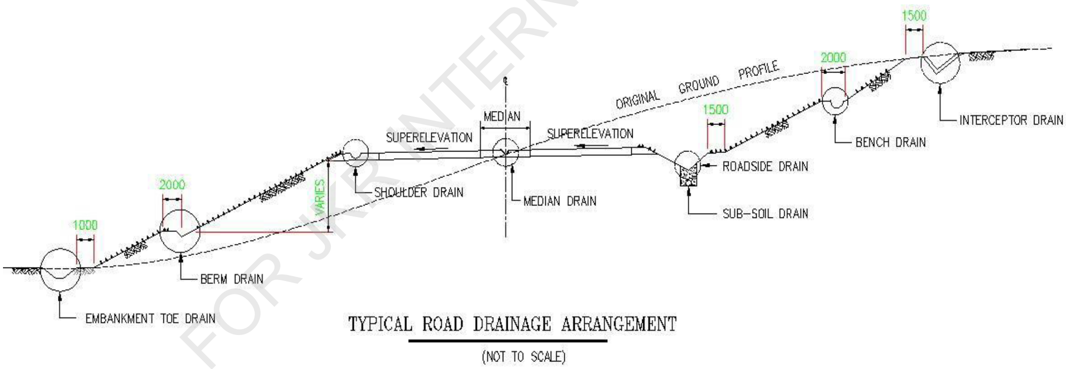


Figure K1: Typical Road Drainage Arrangement

Drainage Design

Component of Surface Drainage

The component and function of surface drainage are as follows :

1. **Interceptor Drain** located along the **uppermost edge of cut slopes** where the cutting begins, and along the edge of the cut slope descending towards the lowest point of the natural watercourse.

2. **Bench Drain** located **longitudinally along the bench of cut slope** or at the cut section to intersect water running on the slope

3. **Roadside Drain** located **along the road edge** and can also cater for the drainage of the abutting developed area. It is also for controlling of water beyond the roadway including water coming.

4. **Median Drains** normally are required in multiple-lane divided highways. Median drains are generally a shallow depressed area, and at intervals the water is intercepted by transverse channels that discharge into a sewer or storm drain The function is to collect surface water which runs towards the central median.

5. **Shoulder Drain** located **along the road shoulder** of the fill section to collect surface water which runs toward the shoulder. The functions of shoulder drains are to prevent water from infiltrating the road surface and carry water away from the roadway.

6. **Berm Drain** located **on the berm of a fill section** to intersect water running on the slope.

7. **7Toe Drain** located **at the base of embankment** wherever the road is in fill section. The functions of embankment toe drains are to collect water that has fallen on the carriageway and the batters of cuttings or embankments to direct to edge of the formation.

8. **Gutter** are small channels provided at the edge of the roadways or shoulders for drainage purposes. They are not covered and can either be V-shaped or egg-shaped. When used with kerbs, gutters are located **in front of the kerbs**. Gutter can be precast or cast-in- situ and commonly used in urban roads or streets.

9. **Sumps** are temporary detention storage between the meeting of two or more drains. It collect water and retain them so as not to flood the other drains. It is rectangular in shape and the depth is deeper than the joining drains. for cut/fill sections, sumps located at;

    a. Berm/ bench drain and the outfall/cascading drain
    b. Toe/ shoulder drain and outfall/cascading drain
    c. Toe/ shoulder drain and roadside drain

Drainage Design

Culvert

Culvert

The purpose of culverts is to convey water under a roadway. It is also helps move water under a road or driveway to a stream, lake or detention basin. For drainage, a culvert is usually prefabricated and comes in standard sizes. Types of culverts commonly used are as follows:

1. Precast reinforced concrete
2. Precast reinforced concrete box culvert
3. Reinforced concrete cast in-situ box
4. Culvert of other material approved by relevant authorities

Design Procedure for Concrete Pipe Culvert

1. Determine peak flow rate, Q. (Average Recurrence Intervals (ARI) is 1 in 50 years)
2. Propose size of pipe culvert. (for maintenance purposes, recommended minimum sizes of culvert shown in **Table 5**).
3. Using Manning's Equation to determine flow capacity, Q_C
4. Flow capacity, Q_C must greater than peak flow rate, Q.
5. Determine fill height on top of culvert.
6. Determine class of pipe culvert. (Z, 1.5Z, 2Z, etc.)

Table K5 : Recommended Minimum size of Culvert (REAM, 2002)

Length of Culvert (m)	Minimum Diameter or Height Culvert (m)
Less than 12 m	1.0
Between 12 to 18 m	1.2
More than 18 m	1.5

Subsoil Drainage

Water control is a very important factor in highway design and construction. Although adequate surface drainage is the first step in ensuring good internal moisture control, a properly designed and incorporated subsoil drainage system is also essential. Subsoil drainage can reduce the soil moisture by keeping the ground water table well beneath the paved surface**.**

Types of subsoil drain commonly used are:

- Single Size Aggregate Filled Trench Lined With Synthetic Filter Cloth
- Subsoil Pipe And Single Size Aggregate Filled Trench Lined With Synthetic Filter Cloth
- Porous/ Perforated/ Slotted pipe With Design Filter Material

Type of Subsoil Drainage:

The type of subsoil drain to be used will depend mainly on the source and the volume of water to be handled. All subsoil drains should be surrounded with an appropriate filter to prevent soil piping and at the same time have adequate conductivity to remove the seepage flow. Granular or synthetic (Geotextile) material can be use as filter membrane and free draining aggregates with or without subsoil pipe is commonly used as the water conductivity medium.

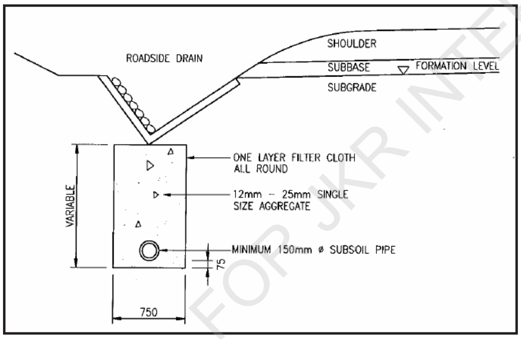


Figure K2: Single Size Aggregate Filled Trench Lined With Synthetic Filter Cloth

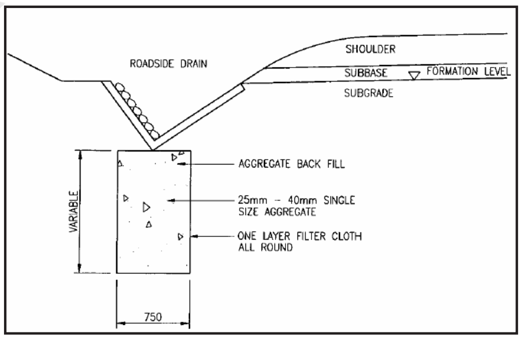


Figure K3: Subsoil Pipe And Single Size Aggregate Filled Trench Lined With Synthetic Filter Cloth

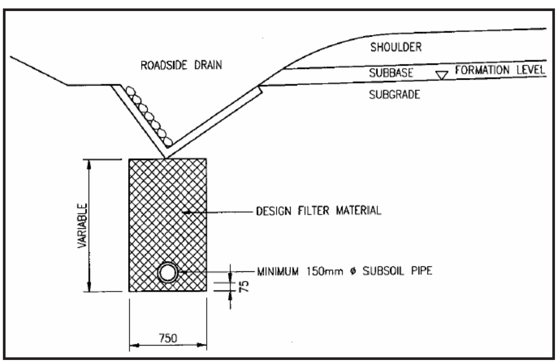


Figure K4: Porous/ Perforated/ Slotted pipe With Design Filter Material

BRIDGE DESIGN

Bridge Design
Backgrounds

Historical Background

Modern road bridge construction in Malaysia began in early twentieth century. Most bridges were constructed using materials and technology available at that time.

The eldest bridges were constructed using steel beams and curve steel plates. This form of construction, which was introduced in the early 1920's, came to known as a buckle plate bridges and was popular until the late 1950's. The earliest reinforced concrete bridges were constructed in the early 1930's. Standard reinforced concrete beams bridges however became common in the 1960s with the introduction of pre-cast reinforced concrete beams.

Pre-cast concrete was first used in Malaysia in the early 1930s. Standard reinforced concrete beam bridges however become common in the 1960s with the introduction of pre-cast reinforced concrete beams.

a. Code of Practice
Malaysia had adopted Euro codes for bridge designs for the loading and design procedure.

b. Geometric Standards
The bridge geometric standards shall be referred to Arahan Teknik (Jalan) 8/86 (with modifications in respect to cross-sectional elements).

Bridge Administration

Bridge administration is a part of road administration. Bridges under federal roads falls under the jurisdiction of the Federal Government.

These include bridges on national highways, roads under Regional Development Authorities and Federal Land Development authorities (FELDA) as well as toll expressways. Federal road bridges come under the administration of the Federal PWD, while toll expressway bridges come under the administration of the MHA.

Other bridges under the jurisdiction of the various state authorities and some private entities. Bridges on state trunk roads comes under the administration of the respective State PWD offices. Other bridges on urban collector roads within local authority boundaries come under the administration of the respective local authorities.

Bridge Numbering System

This system requires the inspector to indicate the route number and road section where the bridge is located and the distance from the route origin to the bridge's centre line. Bridges are labelled with route number followed by a road section number and the distance from kilometer post, e.g FT 003/619/50 bridge is situated at Federal Road 003 in Section 619, 50 meters from the nearest kilometer post.

Bridge Design

Classification of Bridges

Classification of Bridges

Bridges are constructed for various purposes to support roads and highways at strategic points along their routes. Bridge structure are necessary for crossing rivers and valleys, or grade separation with other roads and railways. Other bridges structure also include pedestrian crossing built over roads.

Bridges are generally classified by purposed as follows:

a. Road or Highway Bridges -
Built for the passage of highway vehicles and pedestrians. High way bridges are designed for heavy rolling loads

b. Railway Bridges -
Built to carry a railway over a road, river etc.

c. Flyover or Overpass Bridges
A bridge, road or railway or similar structure that crosses over another road or railway. An overpass and underpass together form a grade separation.

d. Viaduct -
A long bridge like structure, compose of small span, carrying a road or railroad across a valley or other low ground.

e. Bridges for Pedestrian Crossing-
Bridge designed for pedestrians over a road, highway, railways and etc.

Figure L1 : Road and highway bridges

Figure L2 : Jambatan Chenor

Bridge Design

Type of Bridges

Type of Bridges

Different bridges distribute loads in different ways and are suited to different kinds of environments. Here are several main bridge type:

1. **Beam** -A girder or beam bridges consist of a deck supported directly by longitudinal girders or beams. A horizontal beam runs across the gap and is supported by abutment/piers underneath. These girders or beams may be either reinforced concrete or pre-stressed concrete.

2. **Box Girder** - The girders are constructed with a cross-section that is rectangular or box-shaped with the roof and floor acting as flanges and the walls acting as a web.

3. **Concrete Box Culverts** - These consist of box-like concrete frames. It is frequently used over small or intermittent waterways.

4. **Truss** - It is easily characterized by having triangular units along the span of the bridge, the side of which act in tension or compression.

5. **Frame** - A rigid frame reinforced concrete bridge is one in which the piers or abutment are cast monolithically with the main supporting member, so that the abutment can assist in carrying the main supporting member loads.

6. **Slab** - a concrete slab bridge is a wide shallow beam in which the beam itself act as a deck.

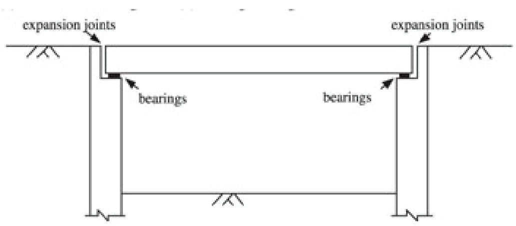
7. **Arch** - There are three type of arch bridge:
   a. The open or spandrel arch
   b. The filled arch
   c. Tied arch

8. Other type are such as suspension bridges, cable-stayed bridges and Bailey bridges.

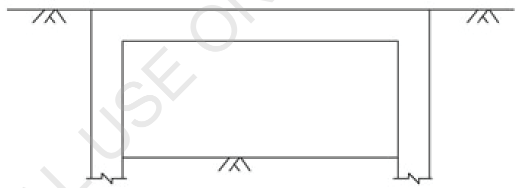
Bridge Design
Bridges System

Conventional Bridge

- **Conventional Bridge means** the structural design, method of construction are not really complex & this type of bridges are widely constructed in many places.
- Simply supported *prestressed beams-slab* concrete bridges either single span or multiple span are the most type that constructed in Malaysia & other countries due to its simplicity & economic.
- However, this type of bridge is not economic in term of its *Life Cycle Cost*.
- Expansion joints in bridge decks are prone to leak & allow the ingress of water, contamination into the bridge deck, bearings & substructure, thereby resulting in severe durability problems.



(*a*) Conventional bridge


(*b*) Integral bridge

Integral Bridge

- **Integral Bridge** is jointless bridge where the deck is continuous & connected monolithically or cast integrally with their substructure.
- Integral bridges accommodate superstructure movements without conventional expansion joints thus eliminate the problems associated with movement joints & bearings.
- With the superstructure rigidly connected to the substructure & with flexible substructure piling, the superstructure is permitted to expand & contract.
- The concept is based on the theory that due to the flexibility of the piling, thermal stresses are transferred to the substructure by way of a rigid connection between the superstructure & substructure.
- A positive connection with the ends of the beams is provided by rigidly connecting the beams by encasing them in reinforced concrete.
- This provides for full transfer of temperature variation & live load rotational displacement to the abutment piling.
- Based on BA42/96: "the design of integral bridges", bridge decks up to 60 m in length and with skews not exceeding 30° are generally required to be continuous over intermediate supports & integral with their abutments.
- The design of integral bridge is complicated by the non-linear soil-structure interaction of laterally loaded piles.

Bridge Design

Component of a Bridge

1. The substructure refers to the elements of the bridge that transfer the loads from the bridge deck & beams to the ground :
   - Abutments/piers,
   - Pile caps
   - Foundation

2. The superstructure component is classified as all the components above bearing:
   - Deck slab
   - Beam
   - Diaphragms

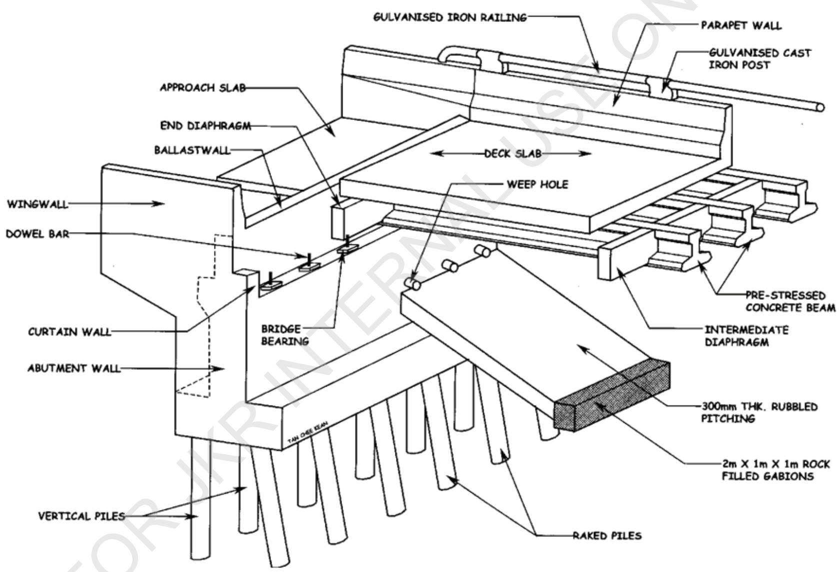


Figure L4 : Typical Components of a Bridge

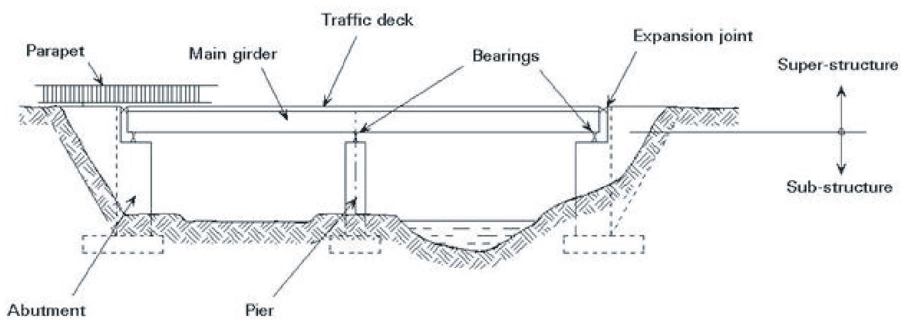


Figure L3 : Typical Bridge Longitudinal Section

Bridge Design

Superstructure

Deck Slab

A **bridge deck** is the roadway, or the pedestrian walkway, surface of a bridge. It works as a platform for vehicles to go through on it and spread the loads (live and dead loads) to components supporters. The deck may be of concrete in turn may be covered with asphalt concrete or other pavement. The concrete deck may be an integral part of the bridge structure or it may be supported.

Type of Deck Slab

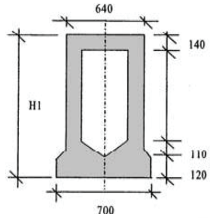
1. Reinforced concrete deck slab
2. Precast reinforced concrete beam-slab
3. Prestressed concrete beam-slab
4. Concrete box girder
5. Composite Deck

Beam

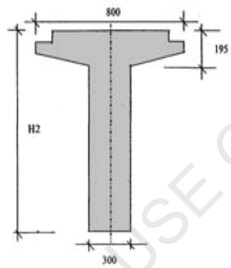
1. Beam/girder is a key component in bridge structure that carries the load from heavy vehicle from the deck slab and parapet . The load then is transferred and distributed to the bearings then to pier or abutment .
2. Concrete beams can be formed either cast in situ or precast, prestressed pre-tension or post-tension .
3. M-beam, Y-beam & Inverted T-beam are not recommended to be used due to difficulty during inspection and maintenance of the deck slab .

JKR Standard Beams are;

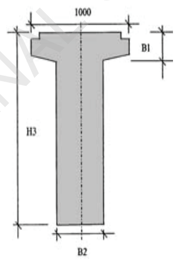
1. Reinforced Concrete Solid Slab (RCSS),
2. Pre-tensioned Concrete Solid Slab (PRSS),
3. Pre-tensioned Concrete Hollow Slab (PRHS),
4. Pre-tensioned Concrete Composite T-beam (PRT)
5. Post-tensioned Concrete Composite T-beam (PTT



PRHS	H1 (mm)	SPAN (m)
PRHS1	500	10.5
PRHS2	600	12.5
PRHS3	700	14.5
PRHS4	800	16.5
PRHS5	900	18.5
PRHS6	1000	20.5



PRT	H2 (mm)	SPAN (m)
PRT1	1250	18.6
PRT2	1350	20.6
PRT3	1400	22.6



PTT (End)	B1 (mm)	B2 (mm)	PTT (Inter.)	B1 (mm)	B2 (mm)	H3 (mm)	SPAN (m)
PTT1	270	550	PTT1	300	360	1800	25.7
PTT2	270	550	PTT2	300	360	1900	28.7
PTT3	270	550	PTT3	300	360	2000	30.7
PTT4	270	550	PTT4	300	360	2100	32.7
PTT5	270	550	PTT5	300	360	2300	35.7
PTT6	270	550	PTT6	300	360	2700	40.7
PTT7	270	550	PTT7	300	360	2850	45.7

Figure L5 : JKR Standard Beams

Bridge Design
Superstructure

Bridge Bearings

A **bridge bearing** is a component of a bridge which typically provides a resting surface between bridge piers and the bridge deck. The purpose of a bearing is to allow controlled movement and thereby reduce the stresses involved. Movement could be thermal expansion or contraction, or movement from other sources such as seismic activity.

Functions of bridge bearing :

1. It spreads the load of the super-structure to the sub-structure.
2. It allows expansion and contraction movements of the structure.
3. To absorb vibration and impact load reduction.

Type of bridge bearing are as follows:

1. Rubber bearing strip
2. Laminated bearing pad
3. Mechanical Pot bearing
4. Steel roller bearing
5. Steel rocker bearing
6. Steel knuckle bearing

Expansion Joints

An **expansion joint** or **movement joint** is an assembly designed to safely absorb the heat-induced expansion and contraction of construction materials, to absorb vibration, to hold parts together, or to allow movement due to ground settlement .

Types of expansion joint :

1. Asphaltic plug joint
2. Compression joint seal
3. Nosing
4. Mechanical finger / comb joint

Parapet

Parapet is a barrier installed / constructed on both sides of the bridge deck slab edge . Commonly used parapet is the type of precast New Jersey Barrier. Its function is to act as a safety barrier to prevent vehicles falling off the bridge and is designed to absorb impact load of vehicle violation .

Bridge Design

Substructure

Abutment

An abutment is a structure that support the super structure on both ends of the bridge. Determining the type of abutment is dependent on the state of the river and the soil profile

The functions of these retaining wall are as follows:

1. Spread the reaction of super structure to the foundation .
2. As a retaining wall reclaimed land .
3. act as a liaison between the super - structure and approach.

Types of abutment :

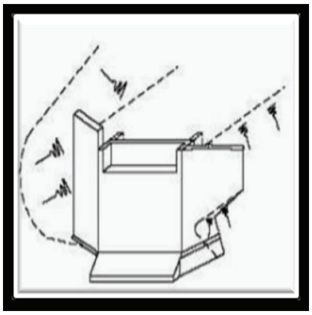
1. Bank Seat - Acts as an end support for the bridge, moves horizontally during thermal expansion and contraction of the deck. The abutment must have adequate weight, and the end span have adequate flexibility, to avoid uplift from live loads or from differential settlement.

2. Retaining wall - A retaining wall is used to hold back an earth embankment or water and to maintain a sudden change in elevation. In case of Retaining wall type Abutment bearing capacity and sliding resistance of the foundation materials and overturning stability must be checked

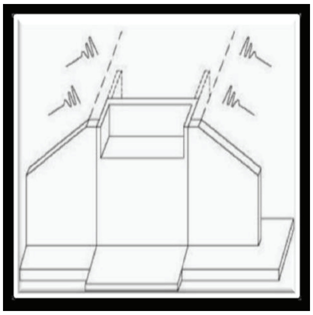
Wingwall

Wingwall is a structure of reinforced concrete walls on both sides of the abutment. Its function is to acts as a hold to fill material from collapsing. The selection depends on the type of material costs and the cost of excavation work.

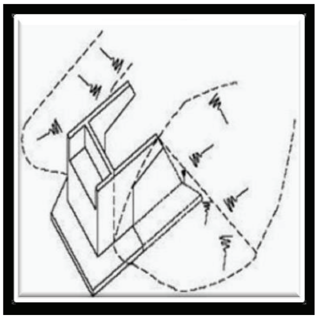
The types of Wing Wall : -
1. Horizontal cantilevered wall
2. Vertical free -standing cantilever wall



At angle to abutment



Perpendicular to abutment

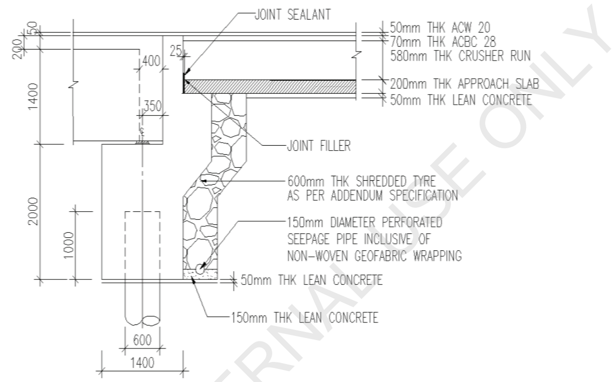


Parallel to abutment

Bridge Design
Substructure

Approach Slab
An approach slab is built under the direction of the road at the end of the abutment Connected with dowel bar above the corbel on the wall abutment.

Functions if approach slab : -
1. Reduce the impact of differential settlement (differential settlement) that may occur between the abutment and approach
2. Generate a comfortable transition (smooth transition) between the flexible structure and the rigid structure



Typical Approach Slab Cross- Section

Its function is to distribute the loads of the superstructure to the ground (foundation). It divides the bridge into a number for a long- span bridges . It consists of crosshead, pole , pile cap and base.

Type of piers :
1. Wall Type - A reinforced wall with the largest lateral dimension more than 4 times the least lateral dimension.
2. Pile Bent - A pile extension pier consist of a drill shaft as the foundation and the circular column extended from the shaft to form substructure
3. Multiple Column - A row of column that supported the bridge deck that spanning across the river.

Foundation
Foundation is a part of structure that come in direct contact with the ground. It is an element that functions is to transfer the load safely to earth . "Safely" means it is safe in terms of the capacity of soil and sediment that do not exceed certain limits .
The type and size of a base used is closely related to the size of the load and also the bearing capacity of soil .
1. Deep foundation is the most common basis used in the construction of a bridge in Malaysia .
2. The type of deep foundation that can be used in designing bridge foundation are:

A bridge pier is a type of structure used to support a travel surface such as a road. The bridge itself connects two points, and it is supported by piers that extend to the ground below or into the water beneath the bridge. It acts as an intermediate support super - structure .

5. Prestressed spun piles
6. RC square piles
7. Bored piles
8. Caisson piles

5. Micro pile
6. Steels H piles
7. Steel pipe piles

Bridge Design

Loading on Bridges

Road traffic actions & other actions specifically for road bridges

1. Loads due to the road traffic, consisting of cars, lorries & special vehicles (e.g. for industrial transport), give rise to vertical & horizontal, static & dynamic forces.
2. The load models defined do not describe actual loads. They have been selected & calibrated so that their effects (with dynamic amplification included where indicated) represent the effects of the actual traffic.
3. The actual loads on road bridges result from various categories of vehicles & from pedestrians.
4. Vehicle traffic may differ between bridges depending on its composition (e.g. % of lorries), its density (e.g. average number of vehicles/year), its conditions (e.g. jam frequency), the extreme likely weights of vehicles & their axle loads & road signs restricting carrying capacity.
5. These differences should be taken into account through the use of load models suited to the location of a bridge (e.g. choice of *adjustment factors* for Load Model 1 & for Load Model 2 respectively).

Permanent Action (Dead load)

- The weight of the materials and parts of the structure that are structural elements, but excluding superimposed materials.
- Dead load is under the classification of Permanent Loads.

Superimposed dead load

- The weight of all materials forming loads on the structure that are not structural elements.(Barriers, overlays,utilities, sidewalks, railings, parapets, signing, utilities and the wearing surface etc.)
- Superimposed dead load is also under the classification of Permanent Loads.

Pier

A bridge pier is a type of structure used to support a travel surface such as a road. The bridge itself connects two points, and it is supported by piers that extend to the ground below or into the water beneath the bridge. It acts as an intermediate support superstructure .

Bridge Design

Aspect of Hydrology In Bridge Design

Hydrology

Technical approaches, policy, guidance, models & related information for analysis & design of bridge crossings.

1. The objectives for the hydraulic design of bridges are:
- The effect of constructing the bridge on the existing water regime should be kept to the minimum.
- The structural design of the bridges should aim to prevent failure under the various types of hydraulic actions.

2. JKR has adopted the following return periods for the estimation of design discharge:
a. Bridges 100-year or the highest recorded flood
b. Culverts 50-year

A freeboard of 1.0 m between the high water level (HWL) & the soffit of bridge beam is recommended. Where the river is navigable by boats/barges/vessels, attention should be given to the vertical and horizontal clearance required by the controlling authority

Design Procedures

1. The preliminary design procedure is shown in the flow chart as below.
2. Having decided that the bridge may be overtopped during high flood, the first attempt in determining the bridge height is to calculate the flood level corresponding to the recurrence period shown in Table above (DJ1/2001).
3. And then add 1.0 m to that level to determine the soffit level of the superstructure of the bridge. If the deck surface level of the bridge calculated based on this soffit level is lower than the general level of the approach road, use the level of the approach road to proceed with the subsequent steps.
4. It should be noted that the Table suggests the minimum recurrence period of flood for determining the lowest soffit level of the bridge only.
5. The suggested recurrence period depends on the category of road & river considered. Should the initial height so determined fail to meet the requirement of subsequent hydraulic & structural consideration, the procedures should be repeated using higher value of bridge height.
6. In calculating the effect due to the action of the highest flood water, the highest recorded flood or the 100-year flood whichever is higher should be used.
7. However, in some cases a submerged bridge condition is to be considered.

Bridge Design

Aspect of Hydrology In Bridge Design

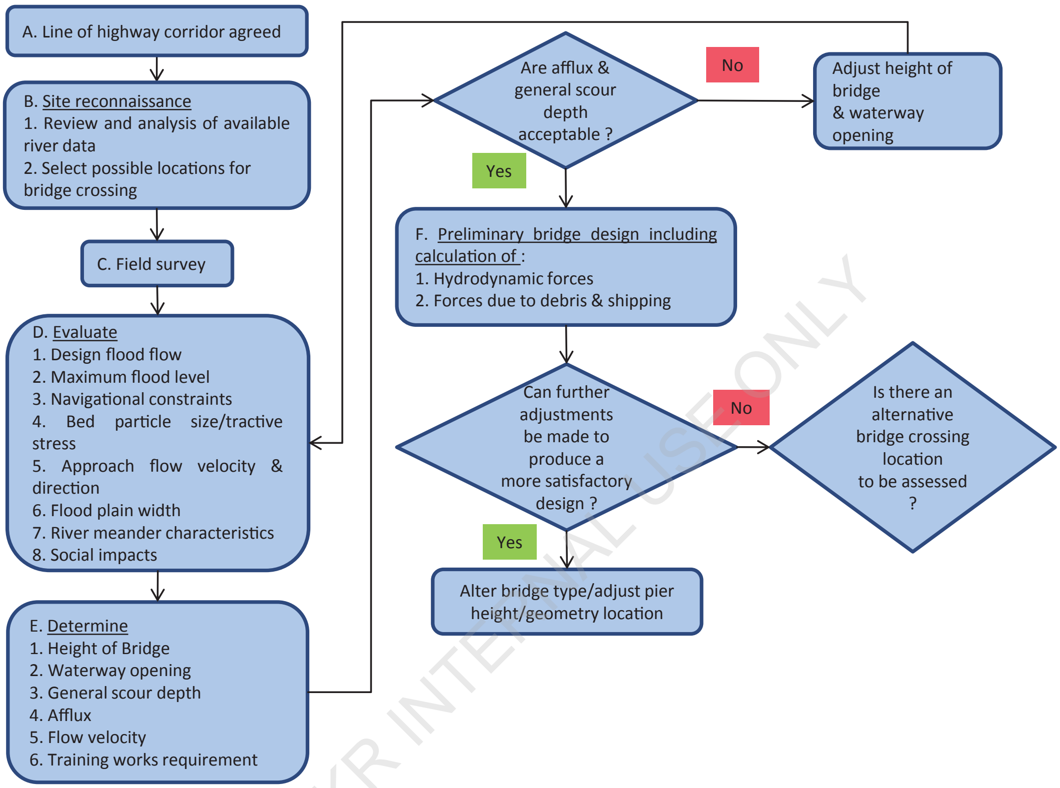


Figure L4 : Flow Chart of Hydrological Analysis for Bridge Design

Review alternative preliminary designs & make final selection for detailed design & possible model investigation

GEOTECHNICAL DESIGN

Geotechnical Design

Geptechnical Standard & Specifications

Topic	Standards & Specifications
Earthworks	JKR/SPJ/2013-S2 & BS 8002
Slope Stabilization	JKR/SPJ/2013-S16
Site Investigation	JKR/SPJ/2013-S17
Geotechnical Design	Euro Code 7
Soil for Civil Engineering	BS 1377: Part 1 to 9 & MS 2038
Code of Practice for Site Investigation	BS 5930 & MS 2038
Retaining Walls	BS 6031
Foundations	BS 8004
Reinforced Fills	BS 8006
Anchors	BS 8081

Table M1 : Standards and Specifications for Geotechnical Works

Geotechnical Design

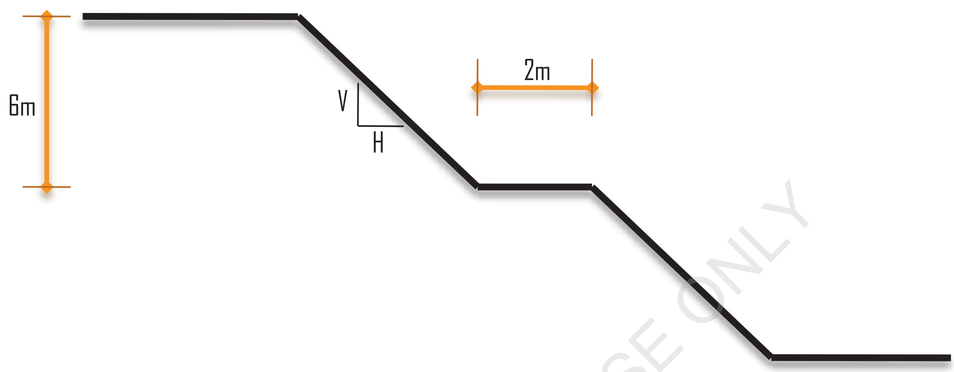
Some Typical Geotechnical Design Criteria for Road Works

Table M2: Geotechnical Design Criteria

DESIGN COMPONENT		MODE OF FAILURE	MINIMUM FACTOR OF SAFETY	DESIGN LIFE (durability of materials)	REMARK
1. Slope / Embankment (not on soft ground)	Unreinforced	1.1 Local & Global Stability 1.2 Bearing (fill)	1.3 2.0	75 yrs	Analysis should be according to GEOTECHNICAL MANUAL FOR SLOPES (1984), GEO Hong Kong
	Reinforced or Treated	1.3 Local & Global Stability 1.4 Bearing (fill)	1.5 1.5	75 yrs	
2. Embankment on Soft Ground		2.1 Bearing (short term) 2.2 Local & global slope stability (short term) 2.3 Local & global slope stability (long term)	1.4 1.3 1.2	75 yrs	5 years post construction settlement : (i) within 50m from structures approach < 100mm } Differential (ii) within 100m remote from structures < 150mm } Settlement (iii) road < 250mm (Total Settlement)
3. Permanent Anchors		3.1 Tensile Resistance 3.2 Resistance at Soil Grout Interface 3.3 Creep/corrosion	2.0 3.0 3.0	75 yrs	Geo Spec 1 (1989), GEO Hong Kong BS 8081
4. Rigid Retaining Structures		4.1 Overturning 4.2 Sliding 4.3 Overall Stability 4.4 Bearing	1.8 1.6 1.5 2.0	75 yrs	Max. permissible vertical movement : 15mm along face of wall Geoguide 1 (1983), GEO Hong Kong Max. permissible lateral movement : 15mm along face of wall Max. permissible differential movement : 1 : 150 along face of wall
5. Reinforced fill walls/structures		External Stability Internal Stability	BS 8006	120 yrs	Verticality: ± 5mm per metre height Alignment along top (horizontal) : ± 15mm from reference alignment Max. permissible differential movement : 1 : 100 along face of wall
6. Individual Foundation Piles (mainly under axial loads)		6.1 Shaft Resistance 6.2 Base Resistance	2.0 3.0	75 yrs	Allowable settlement: 12mm along axis of pile at pile head at design load. 38mm or 10% pile size at pile head at twice design load. Residual settlement not exceed 6.5mm BS 8004 & JKR Road Specification
7. Individual Foundation Piles (mainly under lateral & bending loads perpendicular to axis of pile)		Ultimate Lateral Resistance	2.5	75 yrs	Allowable settlement: 12mm along axis of pile at pile head at design load BS 8004 Max. permissible lateral movement : 12mm perpendicular to axis of pile at design load
8. Pile Group		Block Bearing Capacity	2.0	75 yrs	Allowable settlement: 12mm at Working Load BS 8004
9. Piles as Retaining Structures		As for 4, 6 & 7 above	As for individual foundation piles	75 yrs	As 4 above for rigid retaining structures BS 8004

Geotechnical Design

Slope Profile and Geometry



Fill Slopes and Embankments

- Fills slope and embankment gradient - 1V : 2H
- All untreated fill slopes and embankments shall be designed with 2m berm width and 6m berm height.

Cut Slope

- Cut slope gradient - 1V : 1.5H
- All untreated slopes shall be designed with minimum of 2m berm width and maximum 6m berm height.
- These include cut slopes in residual soils and in completely decomposed rock.

Rock Slope

- All rock slopes shall be analysed and designed.
- Preliminary consideration can be used using 4V : 1H.

Table M3 : Specifications for Earthworks

Items	JKR Road Spec.: SPJ/1998 : Sec. 2: Earthworks
Unsuitable Materials (USM)	- Running silt, peat, top soil, highly organic clay or silt - LL > 80%, PI > 55%, Chloride > 200ppm, Sulphites > 100ppm - Susceptible to spontaneous combustion, pH < 4.5 - Loss of weight > 2.5% on ignition
Trial compaction	- Minimum size 8m x 15m - Fill material for use shall be suitable material - Laid in layers not exceeding 300m compacted thickness - Record type of machine, no of passes & loose depth
Thickness for every layer	Compacted thickness limit to 300mm
Degree of compaction	Based on max dry density B.S.1377 compaction test (4.5 kg rammer) Normal fill : a. Cohesive soil > 90% b. Non cohesive > 95% 300mm subgrade: a. Cohesive soil > 95% b. Non cohesive > 100%
Embankment Slope	Extend each compacted layer to min 600mm beyond the design slope surface
Field Density Test (FDT)	Sand replacement method

Geotechnical Design

Stability and Settlement Problems

Common Solutions Used To Solve Stability & Settlement Problems On Soft Ground & Slope

Slope Protection Methods

RC Retaining Wall
RE Wall
Rock Toe
Gabion
Hybrid Ground Anchor
Soil Nailing
Guniting
Erosion Control Mat
Reinforced Geotextile / Geogrid
Contiguous Bored Pile
Grid Beam

Rock Slope Stabilizations

Rock Anchor / Dowels / Bolts
Buttress Wall
Counter Fort
Guniting
Wire Netting

Ground Improvement Methods

Sand Replacement
Geotextile Reinforced
Preloading with Surcharge
Stage Construction
Preload Surcharge with
Prefabricated Vertical Drain (PVD)
Stone Column
(Vibro- Replacement)
Dynamic Replacement
Dynamic Compaction
Vibro-Compaction
Compaction
Pile Embankment
Micro Piles
Deep Soil Mixing
Expanded Polystyrene (EPS)

Geotechnical Design

Types of Treatment On Soft Ground Problems

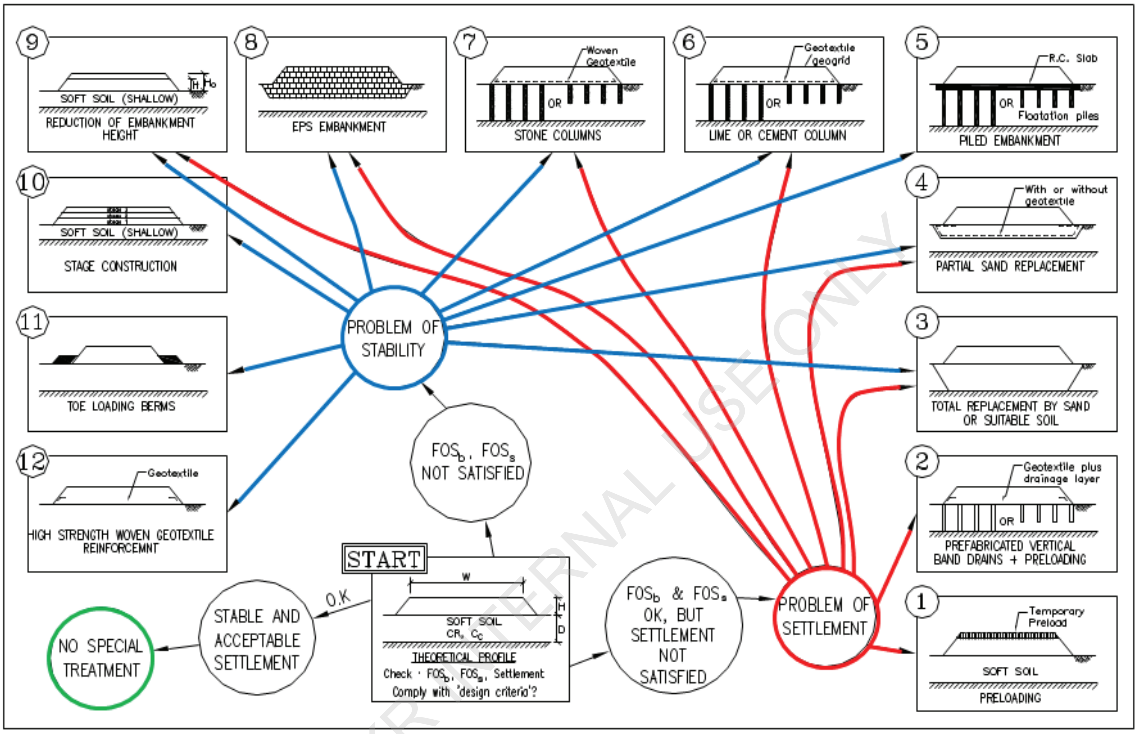
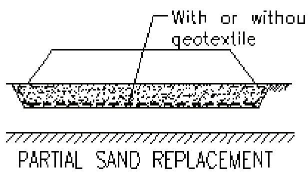


Figure M1:Types Of Treatment On Soft Ground

Geotechnical Design

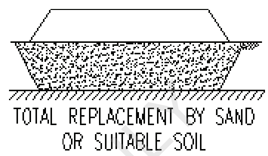
Common Solutions For Stability Problems

Partial Replacement



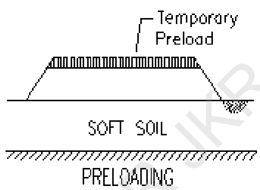
Material : river / mining sand / suitable granular material
Design: stability, settlement, bearing
Parameters : C, , , traffic load , Mv, Pc, Cc, Tv, e_o
Compaction : Max. dry density > 95%
FOS > 1.5

Total Granular Soil Replacement



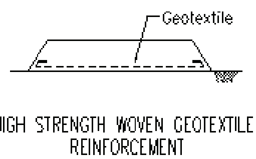
Material : river / mining sand or suitable granular material
Design: stability, settlement, bearing
Parameters : C, , , traffic load , Mv, Pc, Cc, Tv, e_o
Compaction : Max. dry density > 95%
FOS > 1.5

Preloading with Surcharge



Material : granular material (sand, crusher run)
Design : stability, settlement, bearing
Parameters : C_u, , , traffic load, M_v, T_v, C_c, P_c, e_o
Require : 90% settLement on completion of construction
Total residual settlement < 250mm for 5 years post construction
FOS stability > 1.5
Instruments : Settlement plate, surface marker, inclinometer, piezometer

Geotextile Basal Reinforcement



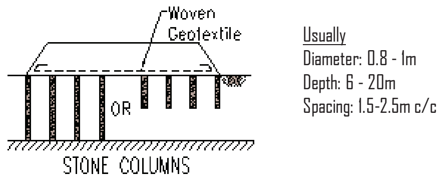
Material : Geotextile
Design : stability
Parameters : Geotextile capacity, Cu, , , traffic load
Characteristic : Tensile strength, separation, Impermeable
FOS > 1.5

Figure M2: Common Solutions for Stability Problems

Geotechnical Design

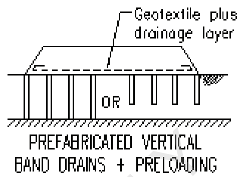
Common Solutions For Stability Problems

Stone Column



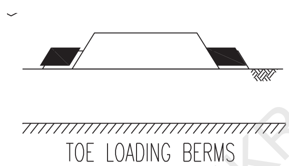
Material : rock / stone size up to 12'
Design: stability, settlement, gain strength
Parameters : loading, column radius & spacing, replacement area,
Cr, Cv, Tv, e_o, Cu, , , Pc, Cc, Mv
Require : 90% settement on completion of construction
Total residual settlement < 250mm for 5 years post construction
FOS stability > 1.5

Preload Surcharge + Prefabricated Vertical Drain



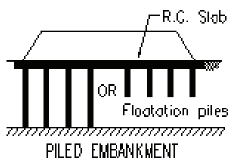
Material : PVD, granular material, geotextile
Design : stability, settlement
Parameters : C_u, , , traffic load, C_v, M_v, T_v, C_c, P_c, C_h, C_v, e_o
Require : 90% settement on completion of construction
Total residual settlement < 250mm for 5 years post construction
FOS stability > 1.5
Instruments : Settlement plate, surface marker, inclinometer, piezometer

Counterweight Berm



Material : geotextile, suitable / granular material
Design: stability
Parameters : C, ,
FOS : > 1.5

Piled Embankment



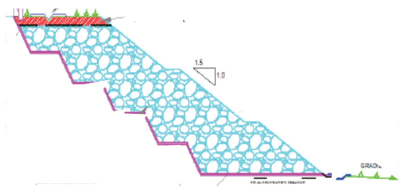
Material : rc pile / spun pile, concrete slab & steel bar
Design: settlement, gain capacity, transition
Parameters : WL, q, f_{cu}, Q_a, Q_u, f_b, f_s, , A_b, A_s
Require : $Q_{u\ bearing}/Q_a > 3.0$ & $Q_{u\ shaft}/Q_a > 2.0$ 'or'
$Q_{u\ bearing} + Q_{u\ shaft}/Q_a > 2.5$

Figure M3: Common Solutions for Stability Problems

Geotechnical Design

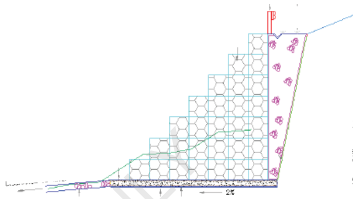
Common Solutions For Stability Problems

Rock Toe at Embankment



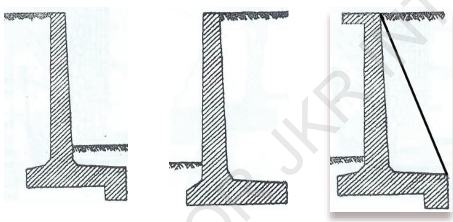
Material : 6’-9’ size of rock, geotextile, subsoil drain at base
Design: stability
Parameters : C, ,
Require : Compaction at base, gradient at 1:2
FOS > 1.5

Gabion



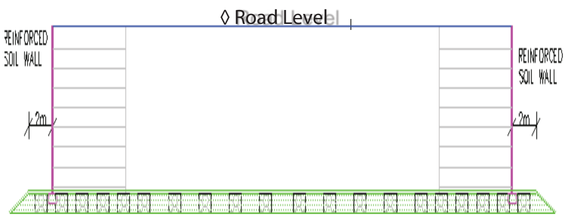
Material : 6’-9’ size of rock, geotextile, sand blanket, coated gabion cage tight with lacing wire
Parameters : C, , , K_a, K_p,
Require : Compaction at base, gradient at 1:2
FOS : overturning >1.8, sliding >1.6, bearing >2, global stability >1.5

RC Retaining Wall



Material : geotextile, granular material, concrete, reinforced bars
Parameters : C, , , Ka, Kp, , Load
Require : Compaction at base
FOS : overturning >1.8, sliding >1.6, bearing >2.0

Reinforced Soil Wall



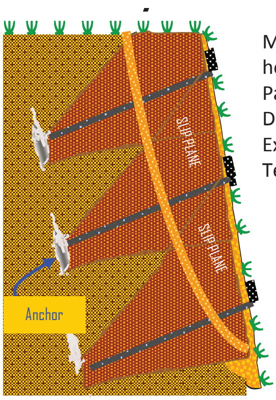
Material : geotextile, granular fill, panel wall, strip bars, capping beam
Parameters : C, , , , K_a, Traffic Load
Require : Design of the foundation for base
External Stability FOS : overturning >1.8, sliding >1.6, bearing >2.0
Internal Stability FOS : tensile of bar & pull out must consider

Figure M4: Common Solutions for Stability Problems

Geotechnical Design

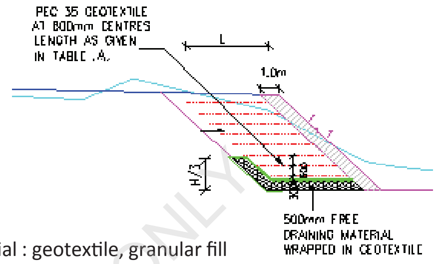
Common Solutions For Stability Problems

Hybrid Ground Anchor



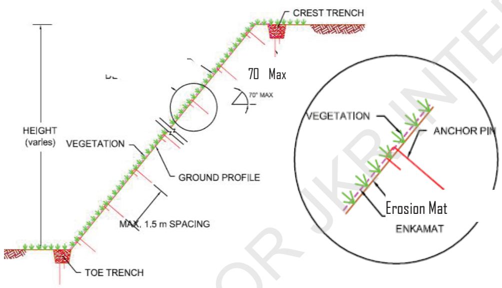
Material : Anchor bar & Swivel head, coupler & locking devices
Parameters : C, , , , Loading
Design : Stability
External Stability FOS : > 1.5
Tensile Resistant FOS : > 2.0

Reinforced Geotextile / Geogrid Structure



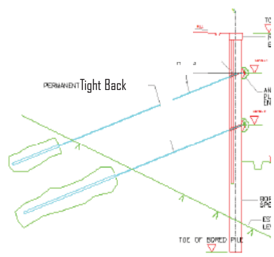
Material : geotextile, granular fill
Parameters : C, , , K_a, loading, geotextile capacity
Compaction : Max. dry density > 95%
External Stability FOS : Slope >1.5
Tensile Resistant of Geotextile / Geogrid must consider

Erosion Control Mat with Hydroseeding



Material : Erosion control mat (many types in the market), hydroseeding, anchor pin etc.
Advantage : High strength surface erosion control mat can prevent surface erosion for slope gradient up to 70

Contiguous Bored Pile



Material : geotextile, anchor bar, bored pile, capping beam
Parameters : C, , , K_a, , f_{cu} Traffic Load
Design : Stability
External Stability FOS : overturning >1.8, sliding >1.6, bearing >2.0
Tensile Resistant : > 2.0; Soil Grout Resistant: >3.0

Figure M5: Common Solutions for Stability Problems

Method Of Stabilizing Rock Slopes

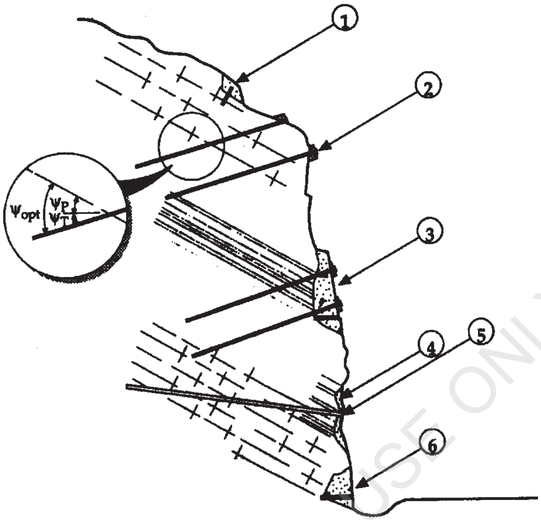


Figure M6: Method of Stabilizing Rock Slopes

1. Reinforced concrete dowel to prevent loosening of slab at crest
2. Tensioned rock anchors to secure sliding failure along crest
3. Tieback wall to prevent sliding failure on fault zone
4. Shotcrete to prevent raveling of zone of fractured rock
5. Drain hole to reduce water pressure within slope
6. Concrete buttress to support rock above cavity

Geotechnical Design

Site Investigation (SI)

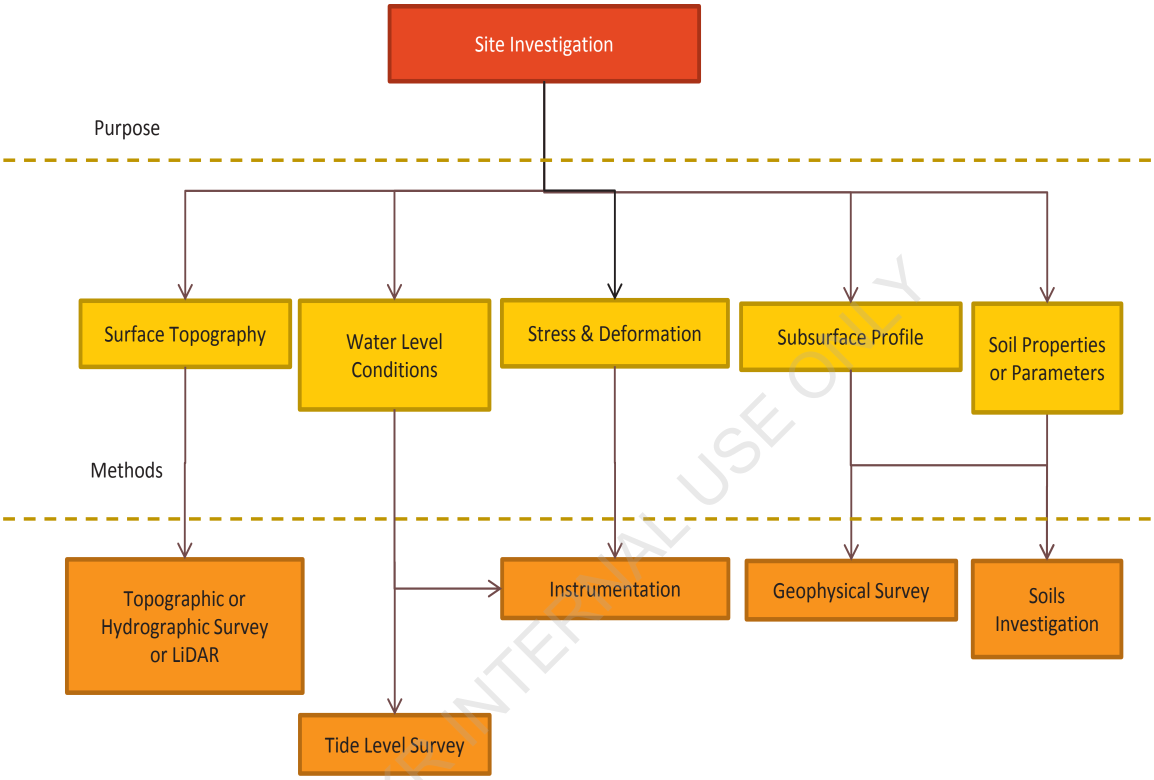


Figure M7: Flowchart for Site Investigation Works

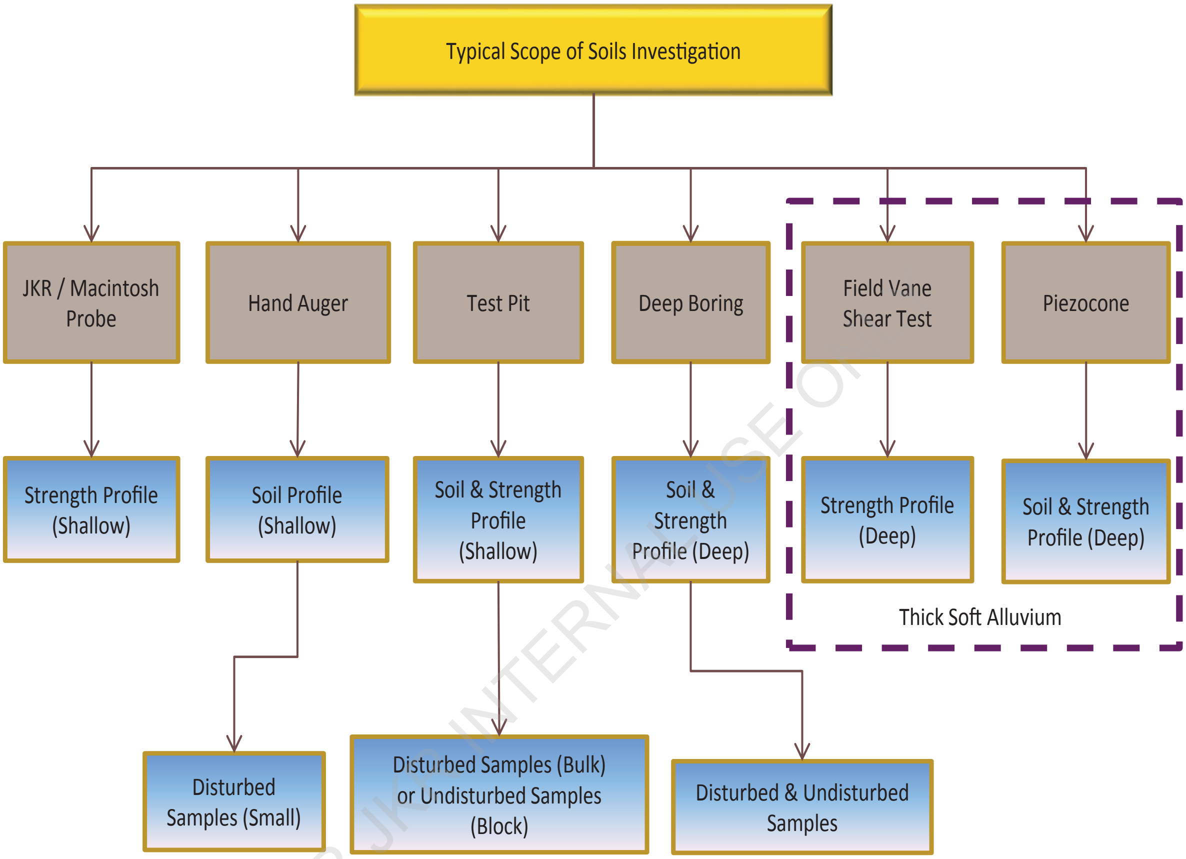
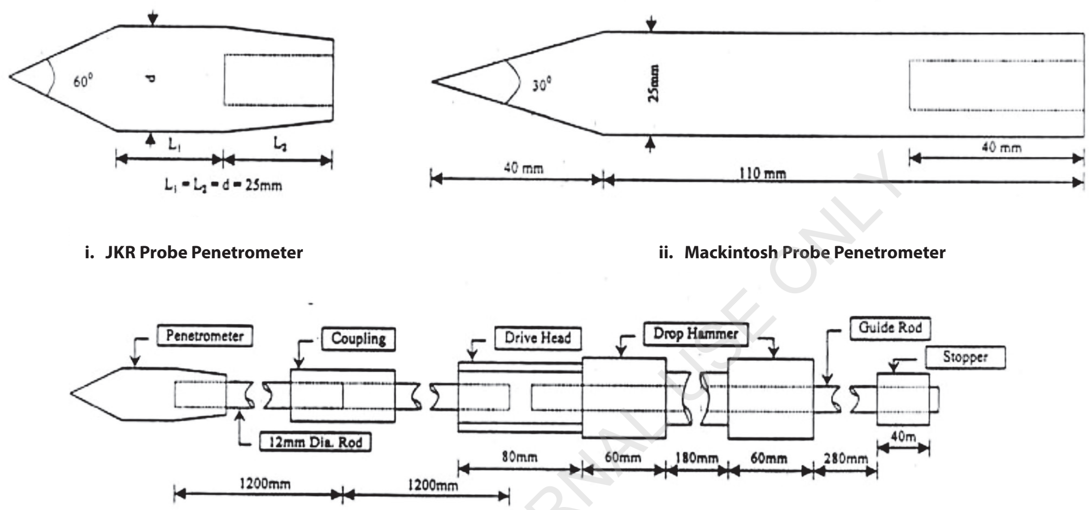


Figure M8: Typical Scope of Soil Investigation

Geotechnical Design

JKR Probe or Mackintosh Probe

SUMMARY OF GEOMETRY AND GENERAL ARRANGEMENT OF JKR PROBE



Type Of Penetrometer	Cone			Dia. Of Rod (mm)	Dia. Of Coupling (mm)	Weight Of Hammer (kg)	Height Of Fall (cm)	Measured Value (blows/ n cm)
	Diameter (mm)	Cross-section (sq. cm)	Angle (Degree)					
J.K.R. Probe	25	5	60	12	22	5	28	n = 30
Mackintosh Probe	25	5	30	13	24	5	30	n = 30

Figure M8: Geometry and General Arrangement of JKR Probe

Geotechnical Design

JKR Probe or Mackintosh Probe

Table M4 : Example of Record of Probe

IKRAM SERVICES SDN. BHD.
IKRAM CENTRAL

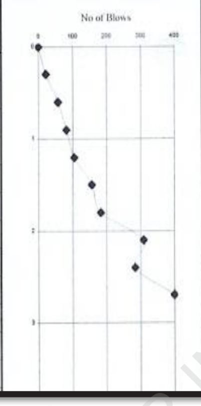
Form : F-WI-12
Issue No : 1
Rev. No : 0
Page No : 1 of 1

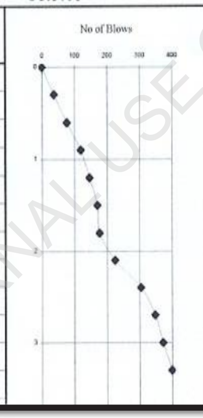
Project : Kegagalan Cerun Di Laluan 055, Jalan Kuala Kubu Baru - Gap, Selangor (Pakej 2) **KM 3.882**

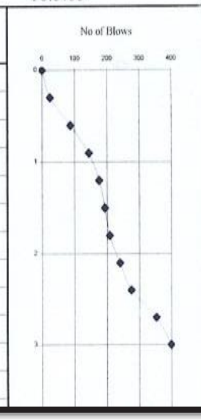
Job No. **39 / 05**

Position No.	JP 1	JP 2	JP 3
R/ Level (m)	61.761	60.711	60.534
Date	16.5.05	16.5.05	16.5.05

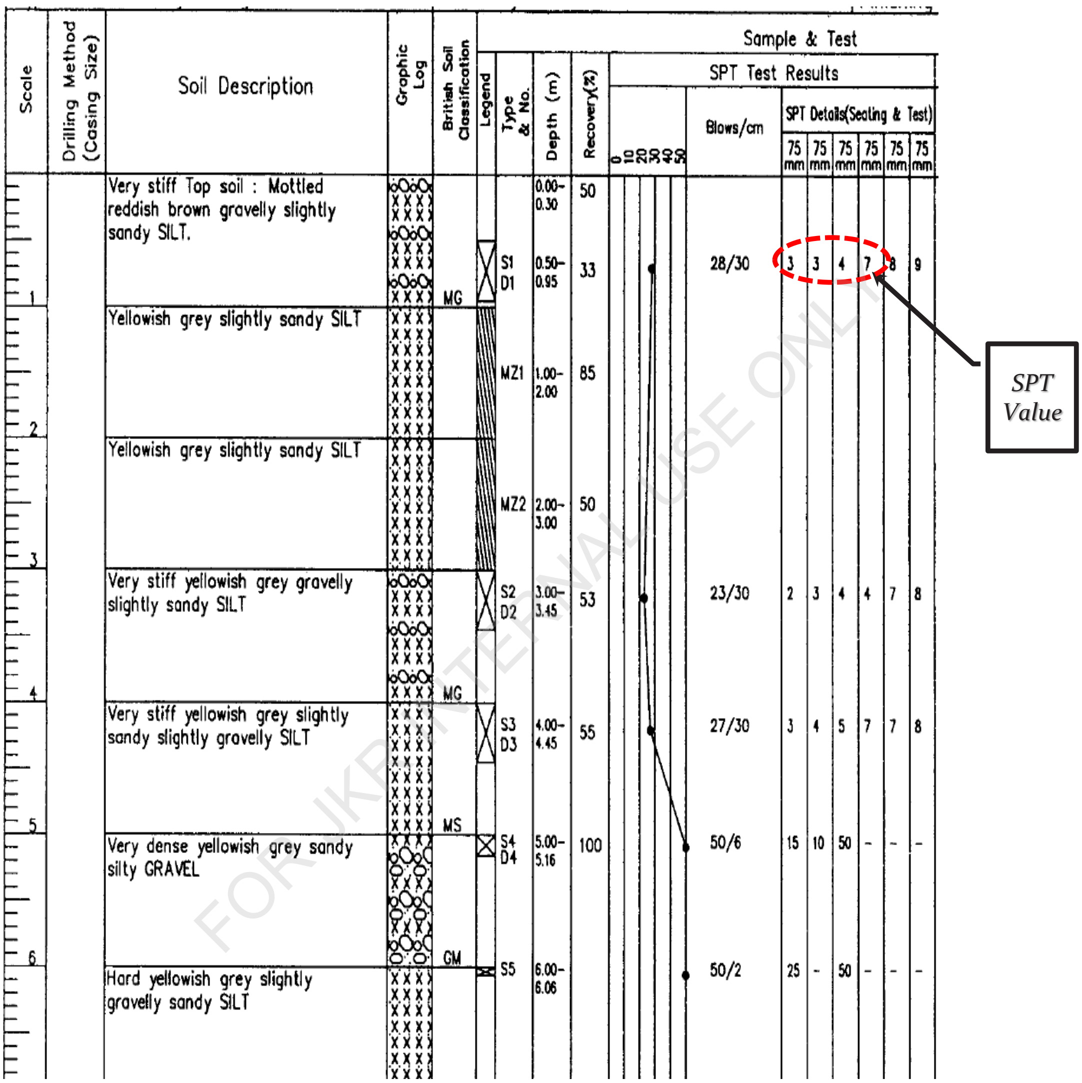
Depth (m)	JP 1 No of Blows	JP 2 No of Blows	JP 3 No of Blows
0.0 - 0.3	22	37	24
0.3 - 0.6	57	76	87
0.6 - 0.9	82	119	144
0.9 - 1.2	105	146	176
1.2 - 1.5	157	170	194
1.5 - 1.8	183	177	209
1.8 - 2.1	309	225	241
2.1 - 2.4	284	304	276
2.4 - 2.7	400	348	354
2.7 - 3.0		372	400
3.0 - 3.3		400	
3.3 - 3.6			







- No. of blows at 0.3m interval
- Maximum depth is 15 meters or terminated at 400 blows per foot whichever come first



Scale	Drilling Method (Casing Size)	Soil Description	British Soil Classification	Type & No.	Depth (m)	Recovery(%)	Blows/cm	75 mm	75 mm	75 mm	75 mm	75 mm	75 mm
		Very stiff Top soil : Mottled reddish brown gravelly slightly sandy SILT.			0.00-0.30	50							
1			MG	S1 D1	0.50-0.95	33	28/30	3	3	4	7	8	9
2		Yellowish grey slightly sandy SILT		MZ1	1.00-2.00	85							
3		Yellowish grey slightly sandy SILT		MZ2	2.00-3.00	50							
4		Very stiff yellowish grey gravelly slightly sandy SILT	MG	S2 D2	3.00-3.45	53	23/30	2	3	4	4	7	8
5		Very stiff yellowish grey slightly sandy slightly gravelly SILT	MS	S3 D3	4.00-4.45	55	27/30	3	4	5	7	7	8
6		Very dense yellowish grey sandy silty GRAVEL	GM	S4 D4	5.00-5.16	100	50/6	15	10	50	-	-	-
		Hard yellowish grey slightly gravelly sandy SILT		S5	6.00-6.06		50/2	25	-	50	-	-	-

Figure M9: Borelog Example- SPT at 1.5m interval

$$RQD = \frac{\sum \text{Length of Sound Core Pieces} > 100\,mm}{\text{Total Core Run Length}}$$

$$RQD = \frac{250 + 190 + 200}{1200} \times 100\%$$

$$RQD = 53\%\ (\text{Fair})$$

Rock Quality Description

RQD (Rock Quality Designation)	Description of Rock Quality
0 - 25%	Very Poor
25 - 50%	Poor
50 - 75%	Fair
75 - 90%	Good
90 - 100%	Excellent

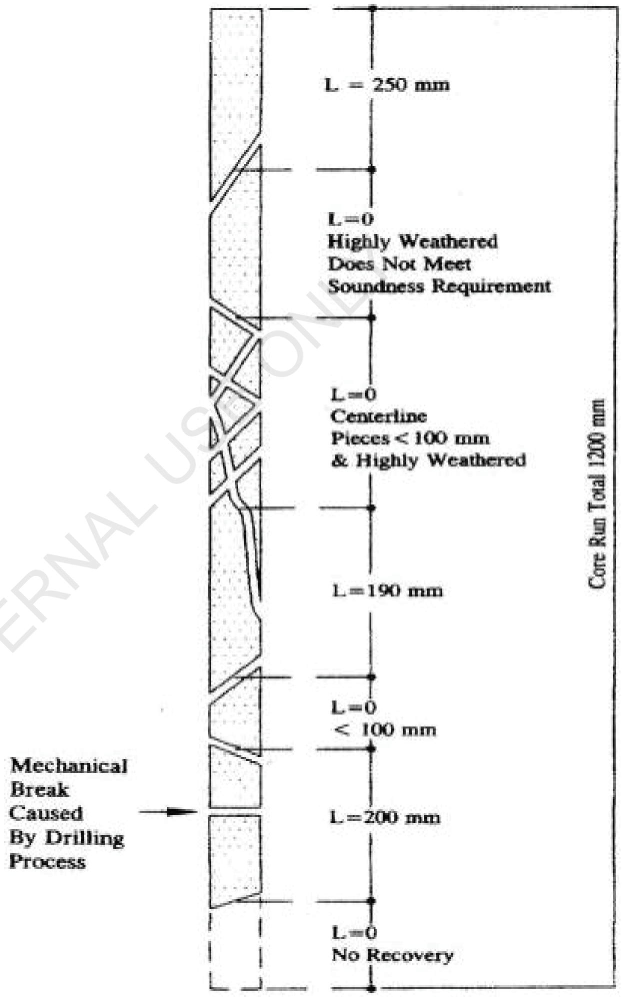
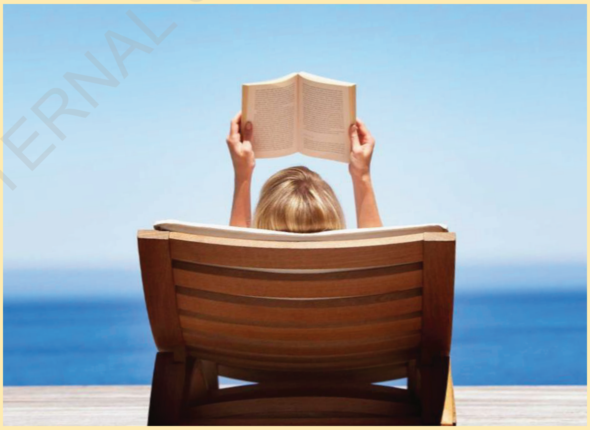


Figure M10: Rock Core Sample



LIST OF TECHNICAL DOCUMENTS

List of Technical Documents

Standard Specifications Published by Cawangan Jalan JKR

1. JKR/SPJ/2015-S1: Standard Specification For Road Works Section 1: General
2. JKR/SPJ/2013-S2: Standard Specification For Road Works Section 2: Earthworks
3. JKR/SPJ/2013-S3: Standard Specification For Road Works Section 3: Drainage Works
4. JKR/SPJ/2008-S4: Standard Specification For Road WorksSection 4: Flexible Pavement
5. JKR/SPJ/2012-S6: Standard Specification For Road Works Section 6: Road Furniture - Sub–section 6.3: Road Markings
6. JKR/SPJ/2008-S8: Standard Specification For Road Works Section 8: Traffic Signal System
7. JKR/SPJ/2008-S9: Standard Specification For Road Works Section 9: Concrete
8. JKR/SPJ/2010-S10: Standard Specification For Road Works Section 10: Piling Works
9. JKR/SPJ/2016-S11 Standard Specification For Road Works Section 11: Prestressing For Structures
10. JKR/SPJ/2013-S13: Standard Specification For Road Works Section 13: Bridge Bearings
11. JKR/SPJ/2013-S14: Standard Specification For Road Works Section 14: Expansion Joints
12. JKR/SPJ/2013-S15: Standard Specification For Road Works Section 15: Parapets
13. JKR/SPJ/2013-S16: Standard Specification For Road Works Section 16: Slope Stabilisation
14. JKR/SPJ/2013-S17: Standard Specification For Road Works Section 17: Site Investigation
15. JKR/SPJ/2017-S19: Traffic Management at Work Zones

List of Technical Documents

Arahan Teknik (Jalan) Published by Cawangan Jalan JKR

1. Arahan Teknik (J) 2A/85: Manual On Traffic Control Devices: Standard Traffic Signs.
2. Arahan Teknik (J) 2B/85: Manual On Traffic Control Devices: Standard Sign Applications.
3. Arahan Teknik (J) 2C/85 (Pindaan 2016): Manual On Traffic Control Devices: Temporary Sign And Work Zone Control.
4. Arahan Teknik (J) 2D/85: Manual On Traffic Control Devices: Road Marking and Delineation.
5. Arahan Teknik (J) 2E/87(Pindaan 2015): Manual On Traffic Control Devices: Guide Sign And Design Application.
6. Arahan Teknik (J) 3/2011: Garispanduan Untuk Memproses Permohonan Pembangunan Tepi Jalan Persekutuan.
7. Arahan Teknik (J) 5/85 (Pindaan 2013): Manual For The Structural Design Of Flexible Pavement.
8. Arahan Teknik (J) 6/85 (Pindaan 2016): Guidelines For Presentation Engineering Drawings.
9. Arahan Teknik (J) 7/85 (Pindaan 2014): Garispanduan Untuk Penyediaan Pelan Pengambilan Balik Tanah Bagi Projek Jalan Persekutuan.
10. Arahan Teknik (J) 8/86 (Pindaan 2015): A Guide On Geometric Design Of Roads.
11. Arahan Teknik (J) 10/86: A Guide To The Design Of Cycle Track.
12. Arahan Teknik (J) 11/87: A Guide To The Design Of At – Grade Intersection.
13. Arahan Teknik (J) 12/87: A Guide To The Design Of Interchanges.
14. Arahan Teknik (J) 13/87: A Guide To The Design Of Traffic Signal.
15. Arahan Teknik (J) 14/87: Model Terms Of Reference For Detailed Ground Survey And Engineering Design Of Roads.
16. Arahan Teknik (J) 16/03 (Pindaan 2015): A Practical Guide For Environmental Protection And Enhancement.
17. Arahan Teknik (J) 20/98: Design Review Checklist For Road Projects.
18. Arahan Teknik (J) 28/2013: Design Checklist For Road Projects.
19. Nota Teknik (J) 18/97: Basic Guidelines On Pedestrian Facilities.
20. Nota Teknik (J) 19/97: Intermediate Guidelines To Road Reserve Landscaping.
21. Nota Teknik (J) 23/03: Guidelines On The Estimation Procedures For Traffic Management During Construction.
22. Nota Teknik (J) 24/05: Hard Material/RockExcavation
23. Nota Teknik (J) 25/07: Guidelines On The Contents Of A Road Safety Audit Report.
24. Nota Teknik (J) 26/08 (Pindaan 2016): An Interim Guide on Standard Bill of Quantities
25. Nota Teknik (Jalan) 27/2012: Terminologi Jalan.
26. Nota Teknik (Jalan) 29/2015: Guidelines For The Provision Of Road Lighting.
27. Nota Teknik (J) 30/2015: Design Guidelines On Safety Facilities for Schools.
28. Nota Teknik (J) 31/2015: Design Guidelines for Emergency Escape Ramp.
29. Nota Teknik (J) 32/2015: Performance Guidelines for Hybrid Ground Anchor.
30. Nota Teknik (J) 33/2015: Guidelines for Motorcycle Facilities.
31. Nota Teknik (J) 34/16: Guidelines for the Selection of Speed Limit

List of Technical Documents

Guidelines Published by Cawangan Jalan JKR

1. A Guide To The Visual Assessment Of Concrete Pavement
2. Manual Fasiliti Keselamatan Jalan
3. Design Guide For Alternative Pavement Structures Low Volume Roads.
4. Construction Supervision Manual For Contract Road Works.
5. Guidelines For Inspection And Testing Of Road Works.
6. A Guide To The Visual Assessment Of Flexible Pavement Surface Condition.
7. Interim Guide To Evaluation And Rehabilitation Of Flexible Road Pavement.
8. Interim Guide On Identifying, Prioritising And Testing Hazardous Location On Roads In Malaysia.
9. Guidelines For The Environmental Impact Assessment of Highway / Road Projects.
10. Road Safety Audit - Guidelines For The Safety Audit Of Roads And Road Projects In Malaysia.

List of Technical Documents

Standard Drawings Published by Cawangan Jalan JKR

1. Standard Drawings for Road Works Section 3: Drainage Works
2. Standard Drawings for Road Works Section 6: Road Furniture
3. Standard Drawings for Road Works Section 7: Road Lighting
4. Standard Drawings for Road Works Section 8: Traffic Signal System
5. Standard Drawings for Road Works Section 9: Motorcycle Lane

Disclaimer

The use of this book, including all its content, is solely at user own risk. PWD Malaysia does not accept any responsibility for any consequences arising from the use of information herein.

The committee has made every reasonable attempt to provide accurate and up-to-date information. This book should only be considered as a general guide and the author does not represent the information as being exact. Readers should independently evaluate the accuracy of the information and its usefulness for any particular need. The information in this book is subject to changes without notice.

This book contained information provided by third parties. The author shall have no liability whatsoever for any such third party information.