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DEVELOPMENT OF ROAD INFRASTRUCTURE SAFETY FACILITY STANDARDS FOR THE ASIAN HIGHWAY NETWORK

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- China (Prof. Xiaojing Wang)
- India (Mr. Tony Mathew)
- Republic of Korea (Dr. Sung-min Cho)
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Executive Summary

Road safety is a sustainable development issue that needs greater attention as road traffic fatalities and injuries place a significant burden on national economies. The Asia-Pacific region accounted for 58% of the global road traffic deaths in 2013. Between 2010 and 2013, while 16 Asian Highway member countries were successful in reducing road fatalities, others failed to do so. The seventh Goal of the "updated Regional Road Safety Goals and Targets for Asia and the Pacific, 2016-2020" emphasizes on developing the Asian Highway network as a model of road safety.

Studies show a strong correlation between infrastructure design and road safety and road engineering and design can influence the severity of the crashes. In this regard, the Annex II to the Intergovernmental Agreement on the Asian Highway Network which entered in to force on 4 July 2005 includes design standards for the Asian Highway Network. However, the design standard does not provide adequate guidance on road infrastructure safety facilities.

As one of the initiatives to address the road safety problem on the Asian Highway Network, the ESCAP secretariat, in association with the Korea Expressway Corporation conducted a study on the development of technical standards on road infrastructure safety facilities for the Asian Highway Network. A detailed literature review on existing standards for infrastructure element design and specification to address road safety in the Asian Highway member countries and other international sources was conducted. A list of 36 road infrastructure safety facilities was prepared. Detailed information on road infrastructure safety practices was collected from five participating countries. A survey was conducted to assess the prevalence, types and design standards of road safety facilities in the Asian Highway member countries in end 2015. The international road assessment programme (iRAP) methodology was used to illustrate how relative risk levels would change if road infrastructure safety facilities were added to the existing Asian Highway standard. It could be concluded that there is potential to promote the use of a broader range of road infrastructure safety facilities for the Asian Highway Network.

The study suggested that the Intergovernmental Agreement on the Asian Highway Network provides an adequate institutional platform for providing guidance to member countries in a number of areas and could further be used for promoting a coordinated approach to the development and adoption of standards of road infrastructure safety facilities. The study emphasizes on providing guidance to the Asian Highway member countries through a dedicated new annex to the Intergovernmental Agreement on the Asian Highway Network. In this regard, proposed mandatory minimum design

standards of road infrastructure safety facilities for the Asian Highway Network which could serve as a draft Annex II bis “Asian Highway Design Standards for Road safety” to the Intergovernmental Agreement on the Asian Highway Network; and related design guidelines of road infrastructure safety facilities which could serve as a recommended practice for the Asian Highway Network have been developed. The study recommended the Asian Highway member countries to consider adopting and implementing technical design standards of road infrastructure safety facilities towards improving road safety on the Asian Highway Network.

1. Introduction

The concept of an Asian Highway network was revived in 1992 under the framework of the Asian Land Transport Infrastructure Development (ALTID) project adopted at the 48th Commission session, following which a number of studies were implemented over the period 1993-2001 to bring the Asian Highway network to over 140,000 kilometres. Subsequently, the network was formalized through an Intergovernmental Agreement on the Asian Highway Network which entered into force in July 2005. Road crashes are a major challenge towards sustainable development of the Asian Highway Network as road traffic injuries place a serious burden on national economies. In 2013, the average road traffic fatality rate for the Asian Highway member countries was lower than the global average and that of the ESCAP region. In the third Ministerial Conference on Transport held in Moscow from 5 to 9 December 2016, the Transport Ministers of the ESCAP member countries adopted the "updated Regional Road Safety Goals and Targets for Asia and the Pacific, 2016-2020"[1]. The overall objective is 50 per cent reduction in fatalities and serious injuries on the roads of Asia and the Pacific over the period 2011-2020. The seventh of the eight Goals is "to develop the Asian Highway network as a model of road safety".

The Pillar 2 of the Global Plan for the Decade of Action for Road Safety 2011-2020 focuses on raising the inherent safety and protective quality of road networks for the benefits of all road users. This is intended to be achieved through the implementation of various road infrastructure agreements under the UN framework, road infrastructure assessment and improved safety-conscious planning, design, construction and operation of roads[2]. In this regard, six activities are included under Pillar 2. Those include promoting safe operation, maintenance and improvement of existing road infrastructure by road authorities and the developing safe new infrastructure that meets the mobility and access needs of all users and encouraging research and development in safer roads and mobility.

The roadway and roadside design elements have an effect on crash risk as those have close relationship with how road users including drivers and pedestrians perceive the road environment. The roadway elements provide guidance to the road users in their decision making process. In particular, the geometry of the road influences the crash rates as well as the severity of the crash. According to the Highway Safety Manual (HSM) of the American Association for State Highway and Transportation Officials (AASHTO)[3], the combination of roadway factor and human factor results in

1 E/ESCAP/MCT(3)/11
2 Global Plan for the Decade of Action for Road Safety 2011-2020. Available at: http://www.who.int/roadsafety/decade_of_action/plan/plan_english.pdf?ua=1
3 AASHTO, 2010. *Highway Safety Manual.* 1st Edn. Washington, DC.

thirty three per cent of all road crashes. However, these proportions may vary depending on the environment. A study on Mumbai-Pune expressway road accidents[4] showed that human factors alone (57%) had the highest influence on the occurrence of the crashes, followed by the combination of human and infrastructure factors (22.5%).

Studies show a strong correlation between infrastructure design and road safety and road engineering and design can influence the severity of the crashes. The design standards chosen for the construction of new roads should ensure that they meet the highest existing safety standards available in the field. In many countries, the installation of barriers to separate opposing directions of traffic and/or different types of vehicles, the application of access control principles, better geometric design of roads to increase the sight distance in curves and the improvement of road shoulders are examples of infrastructure-related measures that have contributed to a reduction in road accidents and fatalities wherever they have been applied. International experiences show that interventions in terms of road infrastructure to improve the driving environment can pay for themselves and the related financial investment can be recovered within a reasonable period of time[5].

The Asian Highway Network consists of eight core routes that substantially cross more than one subregion and a number of other routes within subregions or member countries. Among the former are Asian Highway routes AH1 and AH6 which cross the Korean Peninsula and travel all the way to Europe at the border with Bulgaria and Belarus, respectively. While these core routes offer an interesting promise for enhanced inter- as well as intra-regional connectivity, the sections that constitute them do not fall into the same class of Asian Highway classification and design standards stipulated in Annex II to the Intergovernmental Agreement on the Asian Highway Network in the countries that they traverse. Beside these technical differences, transport operation along the routes is also made difficult by the absence of a common institutional framework to regulate movements across borders.

In the light of the continuing growth of intra-regional trade, there is now concern that these technical and institutional problems could in the short- to medium-term create bottlenecks along these core routes. While harmonization of road construction standards is important, attention should also be given to “above-the-ground” installations, in particular those linked to road safety such as speed reduction devices, roadside safety features etc. Easing drivers’ vehicle operation and increased safety

4 Available at: http://www.jpresearchindia.com/pdf/JP%20Research%20India-ESAR2014.pdf

5 Ishtiaque Ahmed, “Road infrastructure and road safety”, Transport and Communications Bulletin for Asia and the Pacific: Designing Safer Roads, No. 83 (2013). Available from www.unescap.org/sites/default/files/bulletin83_Fulltext.pdf.

require a “predictability of events” along roads and during road trips. Given that increased connectivity will gradually lead to enhanced cross-border road movements, it is highly desirable that this “predictability of events” be uniform along the road infrastructure of the Asian Highway member countries and that standards be established to that effect.

However, the Asian Highway “classification and design standards as stipulated” in annex II to the Intergovernmental Agreement on the Asian Highway network[6] does not provide adequate guidance on the road infrastructure safety facilities that might be considered in addressing road safety on the Asian Highway routes. For example, no information on any proper type of guard fence is provided while it is indicated in a note that “the recommended width of the median can be reduced with the proper type of guard fence”. The above indicates that it would be beneficial for road safety along the Asian Highway routes, if certain standards of the road infrastructure safety facilities could be maintained along the routes.

In this regard, to address the road safety problem along the Asian Highway Network and as a follow on to the previous successful collaborations between ESCAP and the Korea Expressway Corporation (KEC), the ESCAP secretariat, conducted a study during 2015-2017 on the development of technical standards on road infrastructure safety facilities for the Asian Highway Network. The study has been a part of the initiative to achieve inclusive and sustainable development through regional cooperation and integration in transport in the Asia-Pacific region and an activity towards implementation of the Regional Action Programme for Sustainable Transport Connectivity in Asia and the Pacific, phase I (2017-2021).

6 United Nations, Treaty Series, vol. 2323, No. 41607

2. Status of Road Safety in the Asian Highway member countries

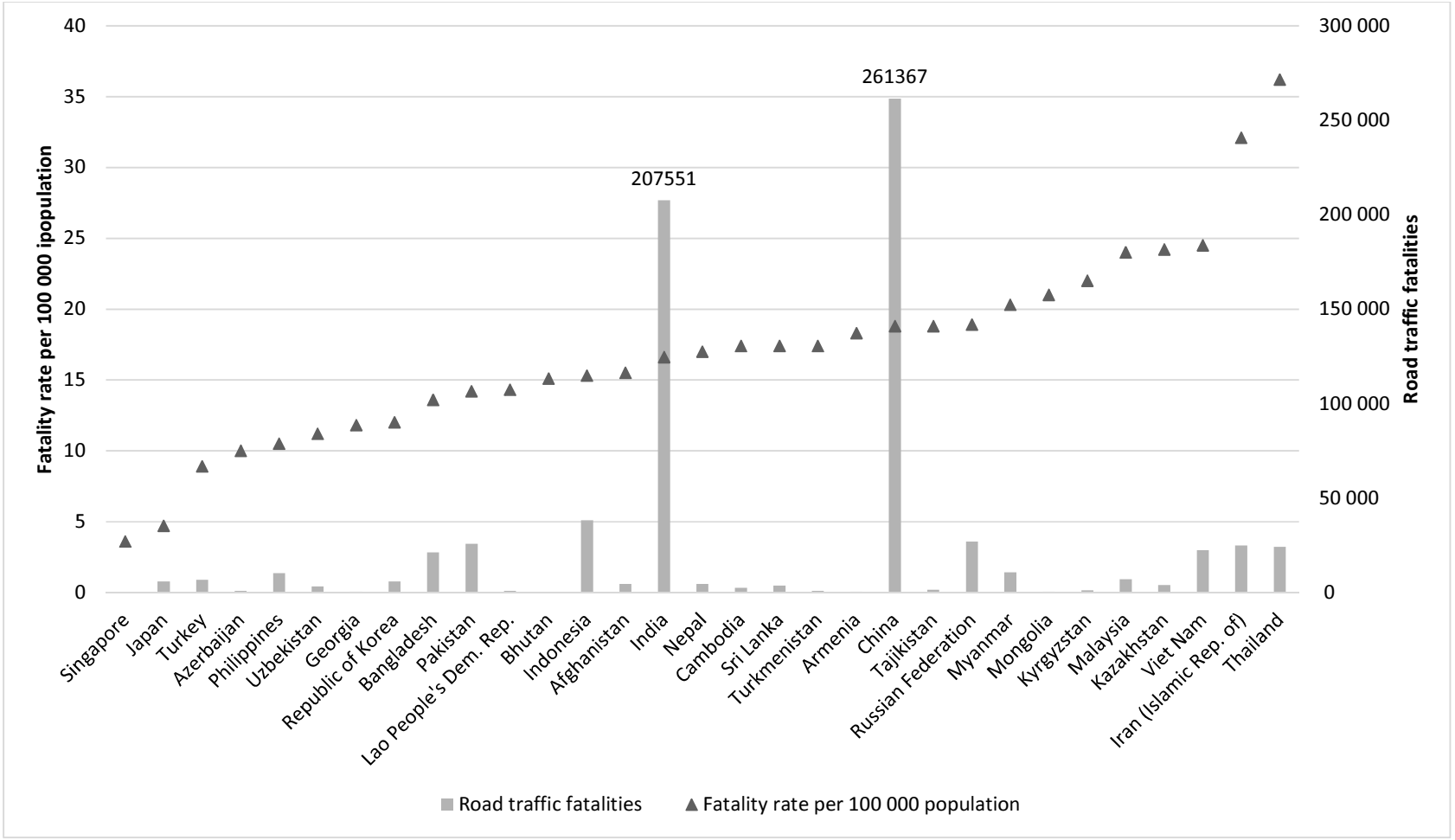
The Asia-Pacific region accounted for 58 per cent of the global road traffic deaths in 2013. Since 2010, there had been a mixed progress in tackling road safety among ESCAP member countries[7]. Road traffic fatalities reduced from 777,000 in 2010 to 733,000 in 2013 representing a reduction of 5.6 per cent. This achievement was prominent in the low income economies with a 24.68 per cent reduction. Lower middle income economies and upper middle income economies were able to reduce the numbers by 5.49 and 5.11 per cents respectively. The number of road fatalities reduced in the SAARC (-8.37%), ECO (-8.05%) and ASEAN (-0.07%) sub regions during the above period. However, in the least developed countries, the trend was opposite, representing a 15.24 per cent increase. Among the ESCAP subregions, the South and South-West Asia were able to achieve a reduction of road fatalities by 8.24 per cent. On the contrary, in the North and Central Asia subregion, road fatalities increased by 5.35 per cent during the above period.

The average road traffic fatality rate (fatalities per 100,000 inhabitants) for the Asian Highway member countries in 2013 (16.95) was lower than the global average (17.4) and the ESCAP region average (18.99). Between 2010 and 2013, while 16 Asian Highway member countries were successful in reducing road fatalities, others (14 countries) failed to do so. Total number of fatalities in 30 of the Asian Highway member countries[8] reduced from 771,271 in 2010 to 729,418 in 2013, representing a 5.43 per cent reduction. Georgia (-24.96%), Singapore (-23.94%) Afghanistan (-23.76%), Turkey (-23.65%), Lao People's Democratic Republic (-23.30%) and Azerbaijan (-21.55%) were able to reduce their national road fatalities by more than 20 per cent. However, indicating an opposite situation, road fatalities in Myanmar (50.61%), Sri Lanka (29.33%), Tajikistan (24.04%), Bangladesh (23.29%), Philippines (22.12%) and Mongolia (21.59%) increased by more than 20 per cent between 2010 and 2013. Figure 1 shows the WHO-estimated number of road traffic fatalities and the fatality rates per 100,000 inhabitants in the Asian Highway member countries.

7 E/ESCAP/MCT(3)/9

8 Data from the Democratic People's Republic of Korea and Turkmenistan for the year 2010 were not available.

Figure 1: Estimated road traffic fatalities and fatality rates in the Asian Highway member countries, 2013



Source: World Health Organization, *Global Status Report on Road Safety 2015* (Geneva, 2015).

Road deaths in member countries tend to be concentrated on a relatively small percentage of roads. In India for example, national highways – which include AH Network roads - represent just 3% of all roads by length yet experienced 33% of the nation's road deaths in 2013. Many sections of the AH Network have alarmingly high rates of trauma.

By comparison, it is not unusual that death rates on such roads are around ten times higher than the United Kingdom's highest risk roads. Furthermore, in each of these cases, there is evidence that reported crash numbers underestimate the true number of deaths on the roads, and so the true numbers could be higher.

It is likely that road safety on the AH Network will become ever more challenging. The world's road systems will continue to rapidly expand, with India, for example, aiming to invest more than $30 billion a year building 66,000 kilometres of new roads at a rate 30 kilometres per day[9]. The World Bank reports that nearly one billion people in rural areas around the world still lack access to all-weather roads.[10] In an increasingly urbanized world, everybody on every trip will at some stage use a road, either as a pedestrian, bicyclist or with a vehicle. But the pressures on road networks are increasing—be it economic and population growth, urbanisation, technology, or changes in how people transport themselves on roads—and the lives of people are at stake. More people riding bikes or driving cars, an ageing population, even expanding the road system can all bring about an increase in road crashes. In Australia, for example, while overall road fatalities are progressively decreasing, the number of cyclist fatalities and injuries has increased significantly[11]. In recognition of both the enormous public health problem that road crashes cause and the potential for large-scale action, the United Nations Sustainable Development Goals set the challenge of halving the number of global deaths and injuries from road traffic crashes by 2020.[12]

9 Planning Commission (Government of India): Twelfth Five Year Plan (2012–2017) Faster, More Inclusive and Sustainable Growth.

10 https://openknowledge.worldbank.org/handle/10986/20093.

11 BITRE. Australian cycling safety: casualties, crash types and participation levels 2015. URL: https://bitre.gov.au/publications/2015/files/is_071_ph.pdf

12 http://www.un.org/sustainabledevelopment/health/

3. Current design standards for the Asian Highway Network

3.1 Asian Highway Classification and Design Standards

Design standards for the AH Network are set out in Annex II on "Asian Highway Classification and Design Standards" to the Intergovernmental Agreement on the Asian Highway Network (referred to herein as the AH Standard)[13] was adopted on 18 November 2003 by an intergovernmental meeting held in Bangkok, was open for signature in April 2004 in Shanghai and entered into force on 4 July 2005. The Annex II to the Agreement provides the minimum standards and guidelines for the construction, improvement and maintenance of Asian Highway routes. In those guidelines, Asian Highway routes are grouped into four classes: primary; class I; class II; and class III, which is specified as the minimum desirable standard. The Standard is summarised in the following table.

Table 1: Asian Highway Standards summary

Highway classification		Primary (4 or more lanes)				Class I (4 or more lanes)				Class II (2 lanes)				Class III (2 lanes)			
Terrain classification		L	R	M	S	L	R	M	S	L	R	M	S	L	R	M	S
Design speed (km/h)		120	100	80	60	100	80	50		80	60	50	40	60	50	40	30
Width (m)	Right of way	(50)				(40)				(40)				(30)			
	Lane	3.50				3.50				3.50				3.00 (3.25)			
	Shoulder	3.00		2.50		3.00		2.50		2.50		2.00		1.5 (2.0)		0.75 (1.5)	
	Median strip	4.00		3.00		3.00		2.50		N/A		N/A		N/A		N/A	
Min. radii of horizontal curve (m)		520	350	210	115	350	210	80		210	115	80	50	115	80	50	30
Pavement slope (%)		2				2				2				2 - 5			
Shoulder slope (%)		3 – 6				3 – 6				3 – 6				3 - 6			
Type of pavement		Asphalt/cement concrete				Asphalt/cement concrete				Asphalt/cement concrete				Dbl. bituminous treatment			
Max. superelevation (%)		10				10				10				10			
Max. vertical grade (%)		4	5	6	7	4	5	6	7	4	5	6	7	4	5	6	7
Structure loading (minimum)		HS20-44				HS20-44				HS20-44				HS20-44			

Notes: Figures in parentheses are desirable values.
Minimum radii of horizontal curve should be determined in conjunction with superelevation.
The recommended width of the median can be reduced with the proper type of guard fence.
The Parties should apply their national standards when constructing structures such as bridges, culverts and tunnels along the Asian Highway.

3.2 Asian Highway Database

The Asian Highway Database includes data on the road attributes specified in the AH Standard. The database also contains provision for additional data, such as numbers of major intersections, traffic volumes and fatalities, although not all countries provide this information. The database is managed by the ESCAP Secretariat and is updated at regular intervals. The Asian Highway network currently comprises about 129,902 km of roads passing through 32 member countries excluding potential Asian Highway routes in China. Table 2 provides a summary of the current AH Network by road class. Multi-lane highways i.e. primary roads and Class I roads make up more than 33% of the network.

13 United Nations, *Treaty Series*, vol. 2323, No. 41607, annex II.

Furthermore, high standard roads comprising the above and Class II roads account for more than 70% of the network.

Table 2: Road Class Composition in the AH Network*

	Primary	Class I	Class II	Class III	Below Class III	Total
Mileage (km)	15,649	28,055	47,592	27,311	10,092	129,902
Mileage %	12.16%	21.80%	36.98%	21.22%	7.84%	100%

* Potential AH Routes excluded

According to the latest updates in 2016, two-thirds of the AH Network is made up of Class I, Class II and below Class III roads. Notably:

- China, India, Iran, Kazakhstan and the Russian Federation account for about half of the AH network.
- China accounts for more than half of all Primary class roads.
- India, Islamic Republic of Iran and Thailand account for more than half of all Class I roads.
- India, Islamic Republic of Iran, Kazakhstan and Russian Federation account for more than half of all Class II AH roads (the Russian Federation alone accounts for almost one quarter of all Class II roads).
- Kazakhstan, Lao People's Democratic Republic, Pakistan and Turkmenistan account for more than half of all Class III Asian Highway roads (Kazakhstan accounts for almost one quarter of all Class III roads).

At present, roads of Class III or lower standards account for about 30% of the network. As the AH network is ever undergoing improvements. It is expected that the percentage of these low standard roads will decrease steadily. Some roads in the AH network traversing mountains have very tight alignment and narrow cross-sections over sheer drops e.g. AH4 China-Pakistan Highway (Karakoram Highway) and AH42 China-Nepal Highway (Friendship Highway). Major transformations were underway for the former and upgrading is being planned for the latter. Nevertheless, a proportion of roads will remain to be Class III or lower standard in the foreseeable future due to economic and technical difficulties for upgrading.

Figure 2. Diversity of AH Network Road Types and Design

Class I Road (AH1) with Footpaths and Lighting approaching a Major Bridge Crossing in Bangladesh (Google Street View 2016)

Climbing Lane on a Class II Road (AH12) in Thailand
(Google Street View 201311)

Interchange between Two Class II Roads (AH1 and AH75) in the Islamic Republic of Iran
(Google Earth 201602)

Class II Road traversing Mountainous Terrains (AH61) in Kyrgyzstan
(Google Street View 201511)

Skewed Intersection on a Class II Road (AH26) in the Philippines
(Google Street View 201510)

Turning Lane on a Class I road (AH6) in the Russian Federation (Google Street View 201307)

Primary Road (AH14) through Mountainous Terrains in China

At-grade Intersection between Two Class II Roads (AH1 and AH84) in Turkey (Google Earth 201106)

4. Study Approach and Structure

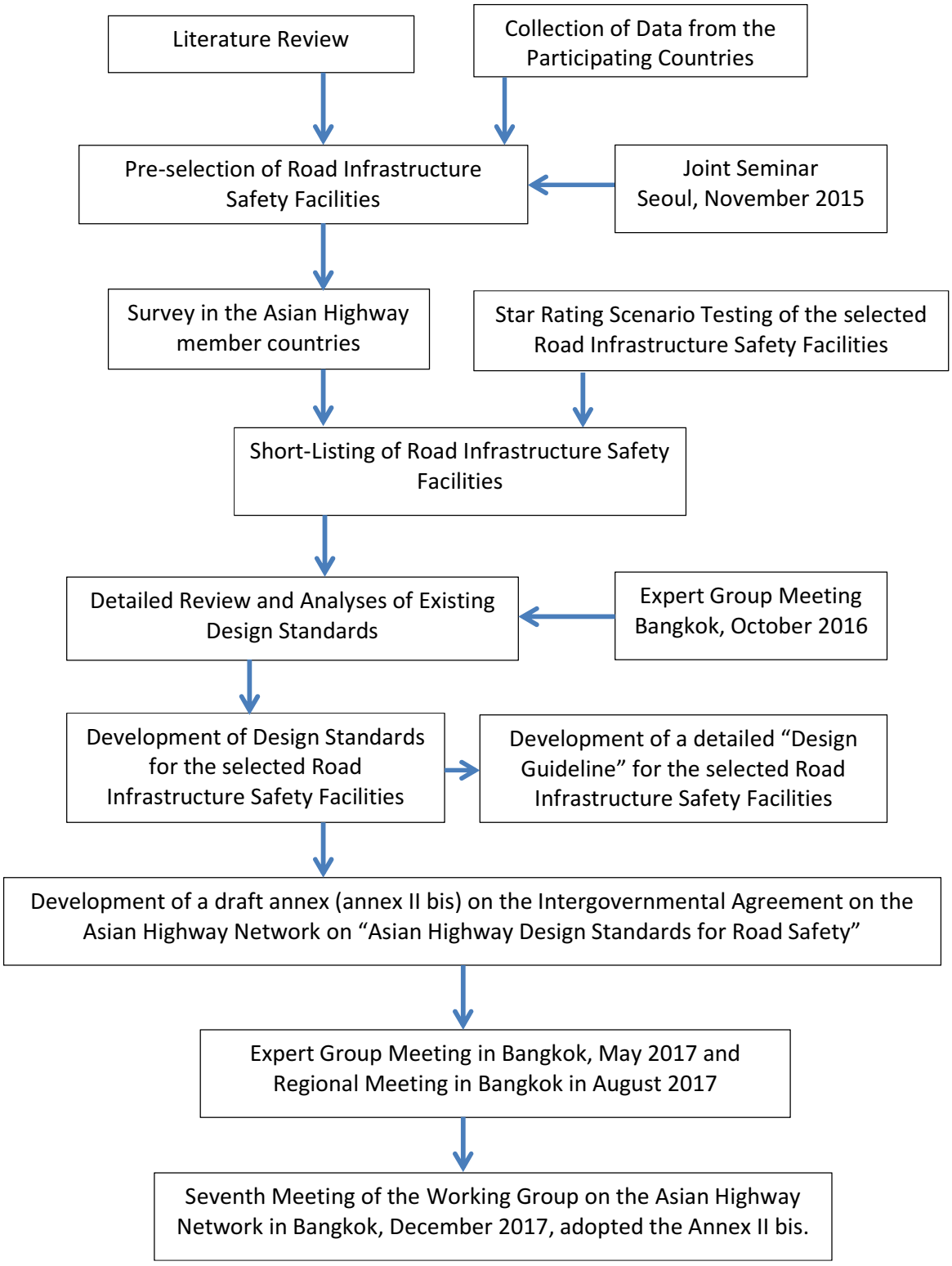
The objective of the study was to provide guidelines and recommendations to the Asian Highway member countries through the followings:

a) Identify road infrastructure safety facilities (RIFs) for the Asian Highway network.
b) Develop design standards for the selected road infrastructure safety facilities (RIFs) for the Asian Highway Network.
c) Provide guidance to the Asian Highway member countries through development of a dedicated new annex (Annex II bis) to the Intergovernmental Agreement on the Asian Highway Network on road infrastructure safety facilities known as "Asian Highway Design Standards for Road Safety"
d) Develop a detailed "Design Guideline" for the selected road infrastructure safety facilities (RIFs) for the Asian Highway network.

To meet the above objectives of the study the following steps were followed:

a) Conduct literature review on existing standards for road safety infrastructure element design and specification to address road safety in the Asian Highway member countries and international sources.
b) Organize a regional Joint-seminar in association with KEC to map out the future activities. This workshop was organized in conjunction with the World Road Congress 2015 (Seoul, November 2015).
c) Collect detailed information from five participating member countries on their current practices and experiences on road infrastructure safety facilities and the existing standards.
d) Pre-select specific elements of the road infrastructure facilities to be considered for the development of regional standards for road safety on the Asian Highway.
e) Identify data requirements and design survey questionnaires for the information (basic data and detailed data) to be collected from the Asian Highway member countries.
f) Conduct a survey in the Asian Highway member countries. Analyse the survey results to find out the current practices and experiences in the member countries on road infrastructure safety facilities.
g) Conduct star rating scenario testing for the pre-selected road infrastructure safety facilities (RIFs) using the international road assessment programme (iRAP) methodology.

Flow chart of Activities



h) Identify a short-list of road infrastructure safety facilities (RIFs) for detailed studies.

i) Organize an Expert Group Meeting to discuss the preliminary findings of the study in October 2016 in Bangkok.

j) Develop design standards for the short-listed road infrastructure safety facilities. This would provide general description of the standards which could be adopted by the Asian Highway member countries as minimum design standards.

k) Develop detailed design guidelines for the short-listed road infrastructure safety facilities (RIFs), which would serve as a design manual and/ guidelines to the Asian Highway member countries.

l) Provide guidance to the Asian Highway member countries through development of a dedicated new annex (Annex II bis) to the Intergovernmental Agreement on the Asian Highway Network on road infrastructure safety facilities.

m) Organize an Expert Group Meeting to in May 2017 to review the study findings and review and refine the draft Annex on road safety facilities.

n) Organize a Regional Meeting in Bangkok in August 2017 to review and finalize draft documents produced by the secretariat on road infrastructure safety facilities.

o) Organize the 7th meeting of the Working Group on the Asian Highway network in Bangkok in December 2017.

Participating Countries

The selected participating countries are located along Asian Highway routes AH1 and AH6. The selected five countries were:

a) Bangladesh b) China c) India d) Republic of Korea and e) Thailand.

Above five countries have different income levels[14] and socio-economic conditions[15,16.] The Republic of Korea is a High Income Country with 12 fatalities per 100,000 populations. China and Thailand are two Upper Middle Income Countries with 18.8 and 36.2 fatalities per 100,000 populations, respectively. India is a Lower Middle Income Country with 16.6 fatalities per 100,000 populations and Bangladesh represents the Low Income Countries with 13.6 fatalities per 100,000 populations, respectively. China and the Republic of Korea represent countries that have reasonably high proportion of access controlled and high speed limit roads in comparison to other countries of the region because of their economies. India and Thailand have a high motor-cycle population and thus

14 List of Country and Lending Groups http://data.worldbank.org/about/country-and-lending-groups

15 Global Status Report on Road Safety, World Health Organization 2013 and

16 Internet Source: http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/

accidents involving two and three wheelers are very high (34% and 73% of the road fatalities, respectively). Bangladesh has a very high volume of pedestrians and thus accidents involving pedestrians comprise of 32% of the road fatalities. It is believed that consideration of countries with different income levels and socio-economic conditions will allow addressing diverse road safety situations.

5. Star Ratings for Road Safety

5.1 Star Rating System

Star Ratings are an objective measure of the likelihood of a crash occurring and its severity on a proactive basis. They draw on road safety inspection data and extensive real-world relationships between road attributes (road features) and crash rates. Research shows that a person's risk of death or serious injury is highest on a one star road and lowest on a five star road[17]. In the Note prepared for the seventieth session of the General Assembly on "improving global road safety", the Secretary General of the United Nations recommended to improve infrastructure, including by targeting the highest volume 10 per cent of existing roads and set appropriate road infrastructure star rating targets for all relevant road users and adopting minimum three-star standards and road safety audits for all new road constructions[18].

5.2 Key road attributes studied by International Road Assessment Programme (iRAP)

International road assessment programme (iRAP) inspections involve surveys to collect digital, panoramic images or videos of roads and GPS location information. These data are then used to record (or 'code') 50 types of road attributes that are known to influence the likelihood of a crash and its severity. The road attributes, which are recorded for each 100 metre segment of road, include those that are known to effect risk for vehicle occupants, motorcyclists, pedestrians and bicyclists. Table 3 provides a summary of the attributes that are recorded in iRAP projects (the complete list of road attributes is available at www.irap.org).

17 Vaccines for Roads, Third Edition published by iRAP.
18 General Assembly Note A/70/386, page 19 para (g).

Table 3: Road attributes recorded by iRAP

Road attribute	Road user			
	Vehicle occupants	Motorcyclists	Pedestrians	Bicyclists
Bicycle facilities				✓
Delineation	✓	✓		✓
Intersection road volume level	✓	✓		✓
Intersection type [a]	✓	✓		✓
Lane width	✓	✓		✓
Median type [b]	✓	✓	✓	✓
Minor access point density	✓	✓		✓
Number of lanes	✓	✓	✓	✓
Passing demand	✓	✓		
Paved shoulder width	✓	✓		✓
Pedestrian crossing facilities [c]			✓	✓
Quality of crossing [d]			✓	✓
Quality of curve [d]	✓	✓		✓
Quality of intersection [d]	✓	✓		✓
Radius of curvature	✓	✓		✓
Pavement condition	✓	✓		✓
Roadside design/obstacles [e]	✓	✓		✓
Shoulder rumble strips	✓	✓		
Side friction/roadside activities			✓	✓
Sidewalk provision			✓	
Speed [f]	✓	✓	✓	✓

a Intersection types includes 3-leg, 4-leg, roundabout, grade separation, railway, median crossing, provision of turning lanes and signalisation. Presence of channelization is also recorded.
b Median type includes centre lines (no median), centre line rumble strips, two-way left-turn lanes, and various width of raised, depressed, or flush medians with and without barriers.
c Pedestrian facilities include signalised and signalised crossings, median refuges and grade separation.
d The quality of crossing, curve, and intersection includes consideration of pavement markings, advance signing, advisory speed limits, and sight distance.
e Roadside design/obstacles includes non-frangible objects such as trees and poles, drains, embankments, cuts, cliffs and the distance of objects from the side of the road.
f Speed is based on 'operating' speed.

5.3 Star ratings of Road Infrastructure Safety Facilities (RIFs)

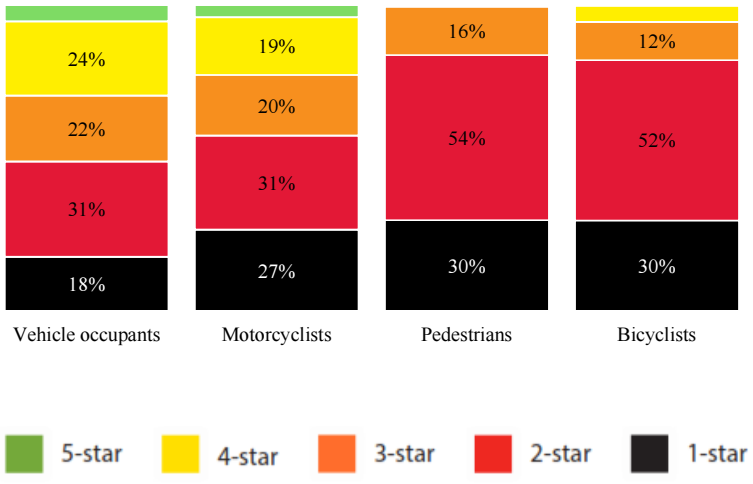
By systematically inspecting a road's infrastructure attributes, it is possible to develop an understanding of the level of risk that is 'built in' to road networks. This provides a basis for targeting high-risk sections of road for improvement before people are killed or seriously injured. Inspections are especially useful when crash data is unavailable or unreliable. These data also provide insights into ways that the AH Standards could be enhanced for safety. The international road assessment programme (iRAP) road safety inspections have now been conducted, or are being conducted, on more than 500,000 km of roads in 62 countries (in 2016). In the context of this project, the iRAP assessment results not only provide an indication of the relative level of risk on the AH Network, but also an indication of the types of road safety attributes that could be considered for inclusion in a new annex on "Asian Highway Design Standards for Road Safety".

iRAP results for a sample of 6,725 km carriageway-km of Asian Highway network roads in 7 member countries have been compiled for this report, as follows:

- Bangladesh (588 carriageway-km)
- India (119 carriageway-km)
- Indonesia (836 carriageway-km)
- Malaysia (1458 carriageway-km)
- Nepal (354 carriageway-km)
- Philippines (725 carriageway-km)
- Vietnam (2645 carriageway-km)

Approximately 42 billion vehicle-kilometres are travelled on the above roads each year.

Figure 3: Star Ratings for a sample of 6,725 km of Asian Highways in 7 countries

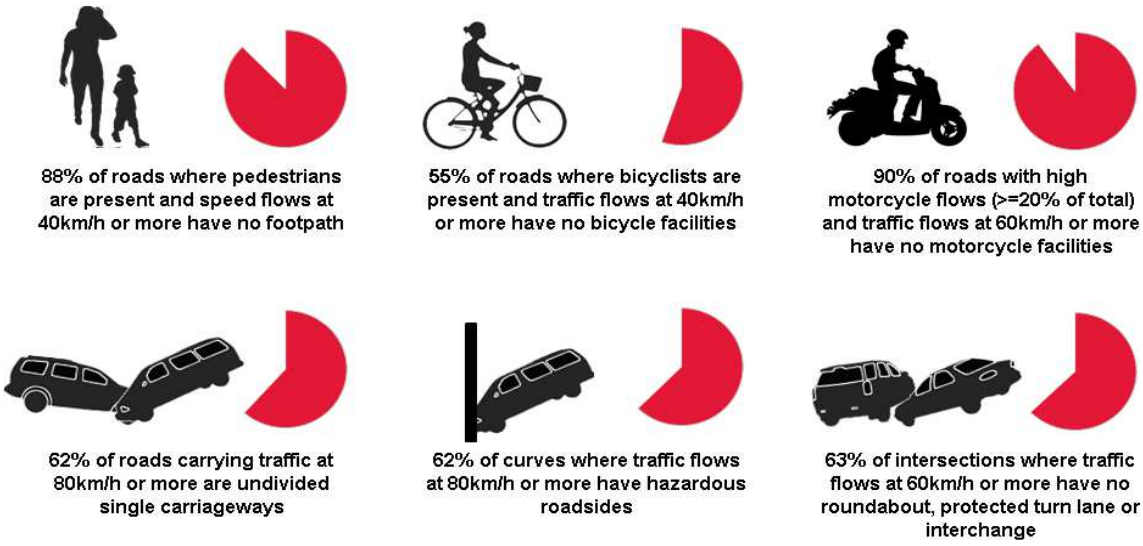


The results for the sample of AH Network roads show that:

- 51% of the roads are rated 3-stars or better for vehicle occupants
- 43% of the roads are rated 3-stars or better for motorcyclists
- 16% of the roads are rated 3-stars or better for pedestrians
- 18% of the roads are rated 3-stars or better for bicyclists.

The inspection data provides a rich source of information that gives insight road safety risk on the sample of AH Network roads. Key road attribute combinations for the sample of roads are summarised below in Figure 3. It is common for roads that carry significant pedestrian and bicycle flows to have no footpaths and bicycle paths. Dedicated motorcycle lanes in countries like Vietnam, where the majority of vehicles are motorcycles, are uncommon. Roadside hazards are common, intersections often lack basic safety elements and roads that carry relatively high-speed traffic often do not have any median separation.

Figure 4: Selected road attributes for a sample of 6,725 km of Asian Highways in 7 countries



The following images were taken from the sample of Asian Highway network roads:

Figure 5: Examples from Bangladesh

5.4 Safer roads investment plans: an example from Indonesia

The road attributes and Star Rating results for the sample of AH Network roads suggest that there is significant room for improvement across all road user types, but particularly for pedestrians and bicyclists. Standard iRAP assessments include an economic analysis of more than 90 proven road improvement options, to generate Safer Road Investment Plans (SRIP). The following is an example of one such SRIP, for sample of AH Network roads in Indonesia.

Table 4: iRAP Safer Roads Investment Plan for a sample of AH Network roads in Indonesia

Countermeasure Type	Length / Sites	KSI Saved	Economic Benefit (Rp m)	Cost (Rp m)	Cost per KSI saved (Rp '000)	BCR
Roadside Safety - Hazard Removal	880 km	25,290	11,391,770	710,770	28,102	16
Shoulder widening	300 km	8,020	3,613,840	211,530	26,364	17
Delineation	380 km	5,420	2,439,410	14,100	853	173
Motorcycle Lanes	150 km	5,190	2,338,440	69,170	13,316	34
Bicycle Facilities	360 km	4,290	1,932,670	161,550	37,649	12
Road Surface Upgrade	110 km	4,250	1,916,060	74,270	10,392	26
Duplication	50 km	3,600	1,619,210	587,480	163,417	3
Pedestrian Crossing	2940 sites	2,970	1,338,550	320,340	95,422	4
Intersection - grade separation	8 sites	2,310	1,041,450	358,720	155,140	3
Roadside Safety - Barriers	50 km	1,770	795,790	43,560	24,653	18
Lane widening	70 km	1,490	669,900	61,500	24,611	11
Pedestrian Footpath	180 km	980	441,770	179,410	182,917	2
Intersection - signalise	80 sites	910	411,690	35,280	38,601	12
Additional lane	40 km	740	332,320	72,640	98,453	5
Intersection - delineation	140 sites	540	241,620	16,980	10,377	14
Intersection - right turn lanes (signalised)	60 sites	310	140,000	29,820	57,100	5
Central Hatching	40 km	200	91,490	1,350	3,966	68
Regulate roadside commercial activity	40 km	180	82,420	3,600	11,715	23
Parking improvements	20 km	120	53,840	11,550	57,536	5
Rumble strip / flexi-post	10 km	110	49,240	690	3,768	71
Railway Crossing	3 sites	90	40,100	2,730	30,698	15
Intersection - right turn lanes (unsignalised)	50 sites	60	26,010	10,080	103,864	3
Median Barrier	1 km	50	22,470	1,100	13,131	20
Total		**68,890**	**31,030,070**	**2,978,230**	**43,229**	**10**

Notes:
- KSI = killed and seriously injured, - Numbers might not add due to rounding
- Countermeasures that span across both northbound and southbound carriageways (such as grade separated intersections and pedestrian overpasses) are reported as 2 sites in this table, with costs and benefits spread between the two.
Note: USD 1 = IDR 8,541 (18 May 2011).

6. Design Standards on Road Infrastructure

Literature review on existing standards for infrastructure element design and specification to address road safety in the Asian Highway member countries and other international sources was conducted. The review included a quantitative element to gauge the breadth of information provided in the documents, and a qualitative elements to develop an appreciation of the level of detail provided. The documents reviewed can be grouped into two broad categories:

a) Standards, which specify design requirements
b) Guides, which provide more generalised information and advice

A complete list of the documents cited is provided in Appendix A. Of these, 119 documents from the following countries and organizations were reviewed for the following analyses. It is worth mentioning here that design guidelines of other member countries were also reviewed at a later stage, but the information is not included in the following analyses.

9 ESCAP member countries with an Asian Highway network:

- Afghanistan
- Bangladesh
- Bhutan
- China
- India
- Indonesia
- Nepal
- Philippines
- Singapore

4 ESCAP member countries without an Asian Highway route:

- Australia
- United Kingdom of Great Britain and Northern Ireland
- France
- United States of America

1 ESCAP Associate Member:

- Hong Kong, China

3 international organizations:

- United Nations ESCAP (Intergovernmental Agreement on the Asian Highway network- Annex II)
- Asian Development Bank (ADB)

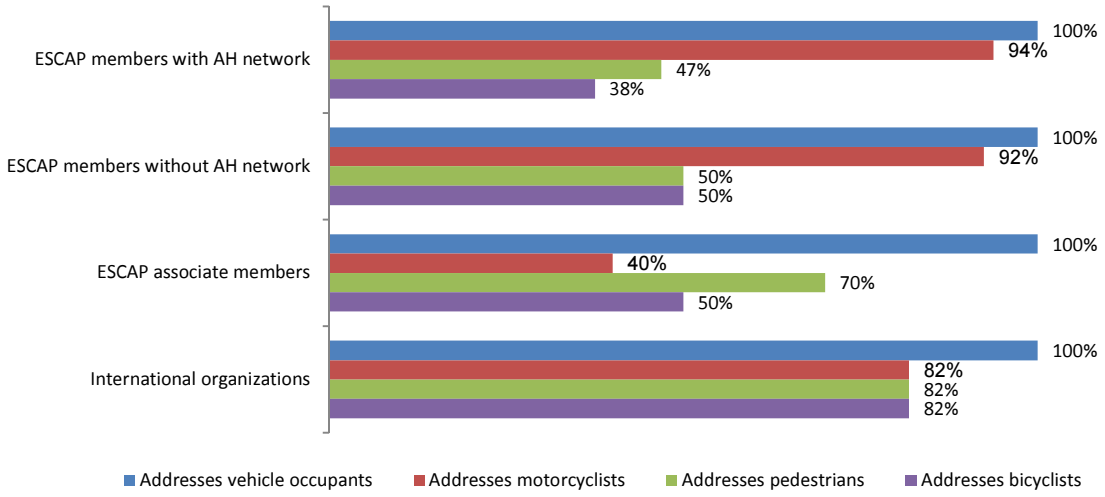
- PIARC (World Road Association)

6.1 Citations by road user

There is a mix of road users present on the AH Network. As such, it is important to consider the extent to which different road users are addressed in the design standards and guides. To examine this, the documents were checked for citations of four key road user groups: vehicle occupants, motorcyclists, pedestrians and bicyclists.

The analysis showed that across the 119 documents reviewed, all made reference to vehicle occupants, most made reference to motorcyclists, and significantly fewer referenced pedestrians and bicyclists (see Figure 6). For example, of the documents from ESCAP members with an AH Network, all the documents reference vehicle occupants; 94% reference motorcyclists; 47% reference pedestrians; and 38% reference bicyclists. This finding is potentially of significance, given that in many of the AH Network countries, vulnerable road users – especially pedestrians – account for a significant percentage of road deaths. The AH Standard makes reference to vehicle occupants, pedestrians and bicyclists, but no reference to motorcyclists is made.

Figure 6: Road user citations in standards and guides reviewed

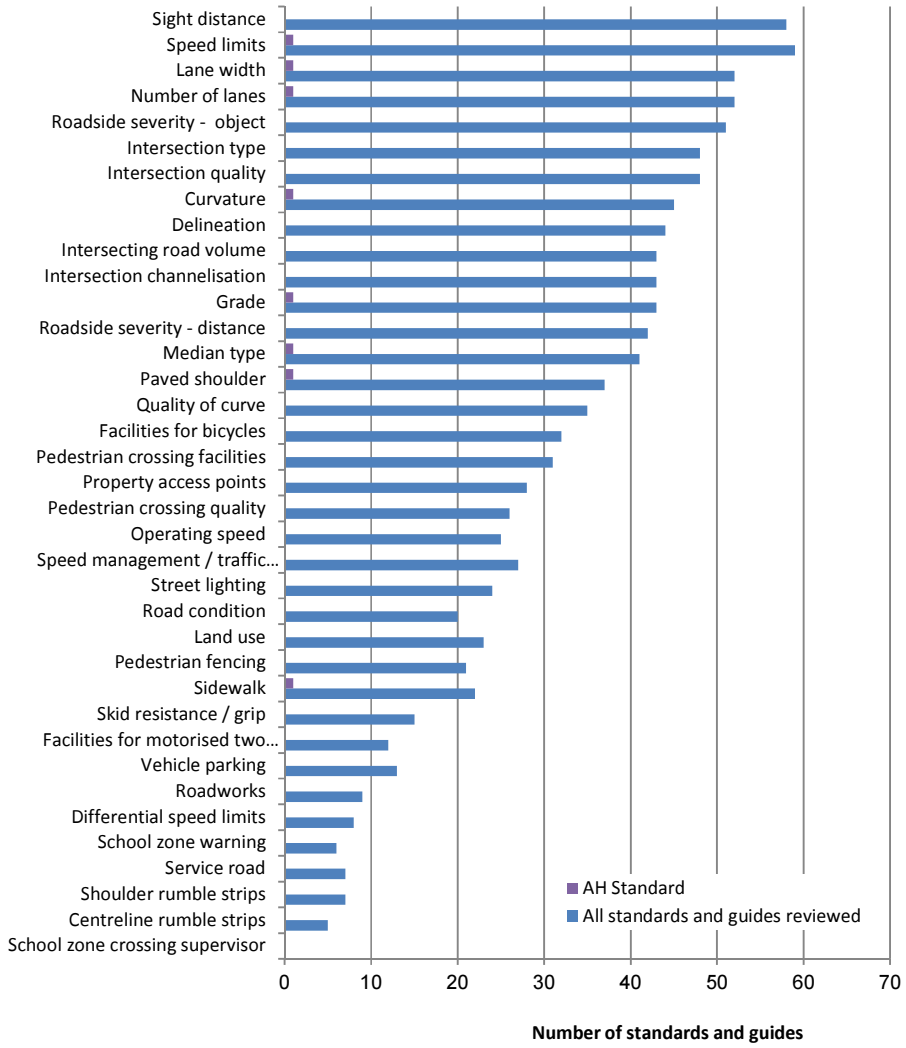


6.2 Citations by road attribute

The extent to which the standards and guides refer to various road attributes is important, as this helps to provide an indication of which road attributes are commonly addressed and a measure of the comprehensiveness of documentation provided. The documents were reviewed for citations of 37

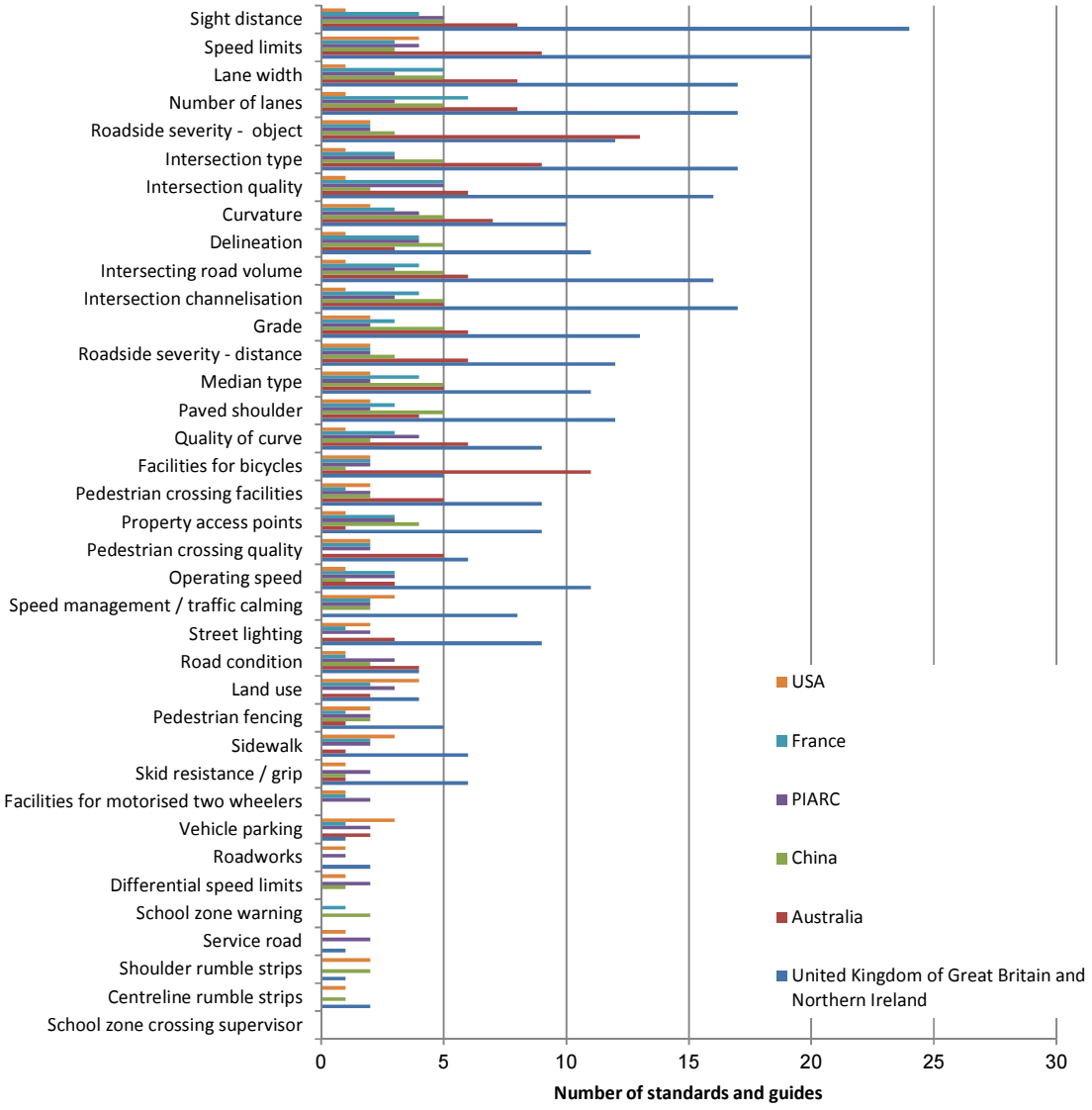
types of road attributes that are known to influence road safety risk. The analysis, summarised in Figure 7, showed that across the 115 documents reviewed, nearly all the 37 road attributes were cited at least once. The exception was 'school zone crossing supervisor', which was not cited. The most common road attribute is 'sight distance', which is cited in 57 documents. By contrast, the AH Standard cites just eight of the road attributes: speed limits, lane widths, number of lanes, curvature, grade, median type, paved shoulder and sidewalk. This analysis showed that standards and guides in use by ESCAP member countries and associate member countries cover a significantly broader number of road attributes, suggesting there is scope to include a larger range of road attributes in the AH standards.

Figure7: Number of standards and guides by road attribute cited



Among the countries and organizations where the sample standards and guides were sourced, the broadest coverage of the road attributes was provided by United Kingdom of Great Britain and Northern Ireland; Australia; China; PIARC; United States of America and France (see Figure 8). Standards and guides from these countries/organizations therefore are potentially useful sources of information for any updates to the Asian Highway Standards. A detailed list of references cited is provided in Appendix A.

Figure 8: Number of standards and guides in selected countries/organizations by road attributes



6.3 Discussion on quantitative analysis

The previous quantitative analyses shows that compared to the sample of standards and guides reviewed, the AH Standard covers a very limited number of road attributes. Among the documents reviewed, the range of detail provided is large as is the degree to which contemporary thinking in road safety is captured. *The AH Standard is among the most limited documents reviewed in terms of detail and contemporary thinking for safety.* In relation to road safety generally, for example, the AH Standard includes only one very general reference, simply saying:

> *While developing the Asian Highway network, Parties shall give full consideration to issues of safety (Article 10 of Section II, Annex II)*

As another example, although the AH Standard cites pedestrians, sidewalks and bicyclists, this is only in an extremely limited form, and is in the context of impeding traffic flows rather than improving safety:

> *Pedestrians, bicycles and animal-drawn carts should be separated from through traffic by the provision, where practical, of frontage roads and/or sidewalks for the sections where smooth traffic is impeded by the existence of such local roads (Article 3 of Section II, Annex II).*

Given that the AH Standard provides minimum standards for a limited number of road attributes, countries are hence required to refer to other designs standards for specifications on other attributes. For example, since the AH Standard does not include roadside safety specifications, countries must draw on other sources for information on issues such as roadside clear zones, slopes and safety barriers. However, the quality of information provided in some other standards and guides is, by international best practice standards, poor. For example, despite the International Road Federation (IRF) recommending that "road authorities in all countries immediately prohibit new installations of 'Fishtail' or 'Spoon' terminals…", these hazardous design safety barrier ends are still included in design standards in numerous countries and continue to be installed on upgraded and new roads. This type of problem is often compounded by the fact that new, smoother pavements invariably lead to higher speeds that significantly increase risk unless ameliorated with safety countermeasures.

On the other hand, there are numerous standards and guides among the sample reviewed that provide comprehensive road safety information. The countries and organizations identified earlier (United Kingdom of Great Britain and Northern Ireland; Australia; China; PIARC; and France) as having broad coverage of road safety attributes also often have detailed, contemporary information on safety issues. Furthermore, design documentation for specific projects conducted in the region may also provide valuable information for particular road attributes. For example, Malaysia and Viet Nam now

have numerous examples of motorcycle lanes which could be drawn on for the development of the AH Standard.

6.4 The Safe System Approach

In addition to information on specific road infrastructure facilities, many of the standards and guides promote principles that are consistent with the "Safe System" approach to road safety. For example, Austroads' *Guide to Road Design Part 4: Intersections and Crossings – General* states:

Adopting a safe system approach to road safety recognises that humans, as road users, are fallible and will continue to make mistakes, and that the community should not penalise people with death or serious injury when they do make mistakes. In a safe system, therefore, roads (and vehicles) should be designed to reduce the incidence and severity of crashes when they occur.

The safe system approach requires, in part (Australian Transport Council 2006):

- *Designing, constructing and maintaining a road system (roads, vehicles and operating requirements) so that forces on the human body generated in crashes are generally less than those resulting in fatal or debilitating injury.*
- *Improving roads and roadsides to reduce the risk of crashes and minimise harm: measures for higher speed roads including dividing traffic, designing "forgiving" roadsides, and providing clear driver guidance. In areas with large numbers of vulnerable road users or substantial collision risk, speed management supplemented by road and roadside treatments is a key strategy for limiting crashes.*
- *Managing speeds, taking into account the risks on different parts of the road system.*

Safer road user behaviour, safer speeds, safer roads and safer vehicles are the four key elements that make a safe system. In relation to speed the Australian Transport Council (2006) reported that the chances of surviving a crash decrease markedly above certain speeds, depending on the type of crash, for example:

- *pedestrian struck by vehicle: 20 to 30 km/h*
- *motorcyclist struck by vehicle (or falling off): 20 to 30 km/h*
- *side impact vehicle striking a pole or tree: 30 to 40 km/h*
- *side impact vehicle to vehicle crash: 50 km/h*
- *head-on vehicle to vehicle (equal mass) crash: 70 km/h*

In New Zealand, practical steps have been taken to give effect to similar guiding principles through a Safety Management Systems (SMS) approach.

Road designers should be aware of, and through the design process actively support, the philosophy and road safety objectives covered in the Austroads Guide to Road Safety (Austroads 2006-2009).

Countries leading in road safety have put these principles into practice with outstanding results. In Sweden, the home of 'Vision Zero', the Road Administration defined a safe road transport system as one where: the driver uses a seat belt, does not exceed the speed limits, and is sober; the vehicle has a five star rating by Euro NCAP (European New Car Assessment Programme); and the road has a four star rating by EuroRAP. Research showed this combination to be a stunning success: just two to three percent of road deaths occurred when these conditions were met, despite them coinciding with 30% of traffic flow. [19] 'Sustainable Safety' is widely credited as underpinning the Netherlands' excellent performance in road safety. Among countries with a population greater than one million people, the Netherlands is often among the top three performers. In 2014, the national death rate was 3.4 deaths per 100,000 population.[20] Sustainable Safety focuses on three design principles for roads: functionality, homogeneity and predictability, and requires the definition of minimum safety levels for all roads.[21] The Netherlands was the first country to set a national Star Rating target for its roads, committing to achieve a minimum 3 star rating for national roads by 2020.

Although the specific approach to creating a safe system might vary from country to country, the principles are universal. The moral imperative for taking this approach is compelling. So too is the economic imperative; the economic savings from targeted safety upgrades typically exceed the cost of their construction and maintenance.[22]

19 Stigson, H., Krafft, M. and C. Tingvall. 2008. 'Use of fatal real-life crashes to analyze a safe road transport system model, including the road user, the vehicle, and the road', Traffic Injury Prevention, 9:463-471.

20 SWOV. 2015. SWOV Fact sheet: Road fatalities in the Netherlands. The Hague, the Netherlands. © SWOV. URL: https://www.swov.nl/rapport/Factsheets/UK/FS_Road_fatalities.pdf

21 Wegman, F., Dijkstra, A., Schermers, G and P. van Vliet. 2005. Sustainable Safety in the Netherlands: the vision, the implementation and the safety effects. Leidschendam. SWOV. URL: http://www.swov.nl/rapport/R-2005-05.pdf

22 McMahon, K. and S. Dahdah. 2008. The True Cost of Road Crashes: Valuing life and the cost of a serious injury. Hampshire, UK. © iRAP. URL: www.irap.org

6.5 Additional Design Standards Reviewed from International Sources

A diverse source of references was reviewed:

International Organizations

- UNESCAP – Intergovernmental Agreement on the Asian Highway Network
- UNECE Trans-European Transport Network (TET-N)
- International Road Assessment Programme (iRAP)
- World Road Federation (PIARC)
- United Nations Road Safety Collaboration
- World Bank Global Road Safety Facility (GRSF)
- International Road Federation (IRF)
- Asian Development Bank (ADB)
- Federation of European Motorcyclists Association (FEMA)

Comparison- Countries and Regions

- Australia
- France
- Germany
- Hong Kong, China
- Qatar
- Netherlands
- Norway
- Sweden
- United Kingdom
- United States

The references cover some of the latest publication releases e.g. the Road Safety Manual of the World Road Federation (PIARC) released in 2015.

Among the comparison countries or regions, emphasis is given to countries with good safety performance and standards or practices:

- Best performing countries (fatalities per 100,000 population): UK, Sweden, the Netherlands, Norway
- Sustainable Safety concept: the Netherlands
- Self-explaining Roads concept: the Netherlands

- Vision Zero concept: Sweden, Norway
- Traffic Calming and Bicycles: the Netherlands
- Forgiving Roadside concept: United States

About the Trans-European Road Network (TERN)

The TERN project is coordinated through the United Nations Economic Commission for Europe (UNECE). TERN consists of a well-developed network of high quality trunk roads. The related Trans-European Motorway (TEM) project is an ongoing initiative to construct 12,000km of TERN motorways across the eastern part of Europe and bordering countries. Both TERN and TEM overlap with the AH Network in several countries, notably Turkey, Russian Federation, Armenia, Azerbaijan and Georgia. Important documents including design standards from the TERN and TEM projects were reviewed. Besides serving as a model for the AH Network, it is essential to take into account TERN and TEM standards for overlapping TERN/TEM and AH routes.

The Convention on Road Signs and Signals Vienna (8 November 1968)

This convention, also known as the Vienna Convention, lays down a system of road signs, signals and symbols and road markings for signifying a certain rule or conveying certain information to road-users. The system is extensively used by both countries joining and not joining the convention. There are 14 parties to the Convention which are member countries of the AH Network (October 2016):
Following the opening for signature of the Vienna Convention, the United Nations Economic Commission for Europe (UNECE), considering that it was necessary to achieve greater uniformity in the rules governing road signs and signals in Europe, asked the UNECE Group of Experts on Road Traffic Safety to prepare a draft Agreement supplementing the Vienna Convention. This is known as “The European Agreement supplementing the 1968 Convention on Road Signs and Signals” with its additional protocol. Among the AH Network member countries, this agreement was only signed by Georgia and the Russian Federation.

The Vienna Convention is relevant since road signs, signals, symbols and road markings are themselves crucial to road safety. They are also integral components of many road safety infrastructure facilities. It may be noted that the Vienna Convention is not sufficient by itself to function as a design standard or guideline, and it is up to individual countries and organizations to develop design standards and guidelines on the basis of the convention.

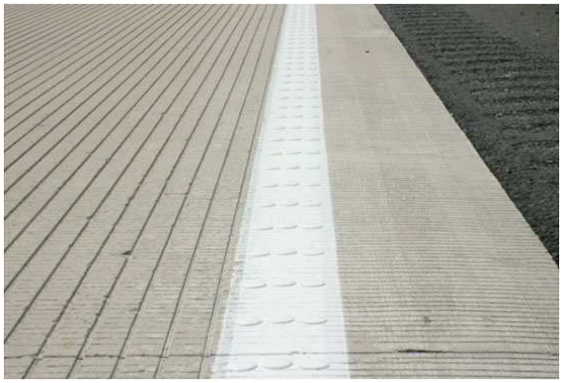
7. Selected Road Infrastructure Safety Facilities for the Asian Highway

7.1 Pre-selection of Road Facilities

There are good evidences that addition of road infrastructure safety facilities would prevent deaths and serious injuries and would be economically viable. The review of existing design standards showed that there is a large range of road safety attributes (road infrastructure safety facilities) cited in road design standards and guides in use among Asian Highway member countries, many of which are not included in the current Annex II to the Intergovernmental Agreement on the Asian Highway Network. Based on this information available through the review of literature, the following road infrastructure facilities (RIF) were pre-selected for consideration in the study.

A. Delineation

A-1. Line marking



A-2. Chevron markers

A-3. Raised reflectorized pavement markers

A-4. Flexible delineator posts

A-5. Coloured lanes

B. Roadsides and medians

B-1. Roadside barrier

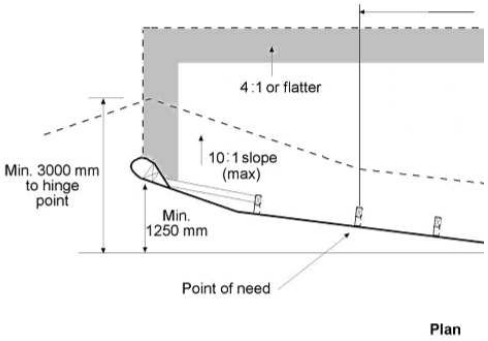
B-2. Median barrier

B-3. Buffer to protect head light from opposite direction

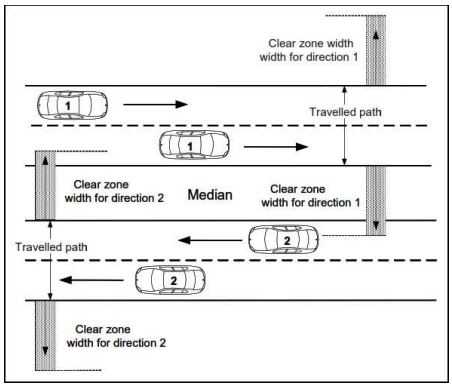
B-4. Central hatching / wide centreline

B-5. Crash cushion with channelization

B-6. Safety barrier end treatment



B-7. Clear zones



C. Pavement

C-1. Enhanced skid resistance (anti-skid pavement)

C-2. Centerline / edgeline rumble strips

D. Pedestrians

D-1. Pedestrian crossing

D-2. Sidewalk (footpath)

D-3. Pedestrian fences

D-4. Pedestrian refuge island

E. Intersection

E-1. Protected turn lane (pocket lane for turning)

E-2. Intersection channelization

E-3. Roundabout

F. Speed control and regulation

F-1. Speed hump

F-2. Visual traffic calming

F-3. Automatic speed cameras

F-4. Variable speed limits

G. Bicycle and motorcycles

G-1. Bicycle lane

G-2. Exclusive motorcycle lane

G-3. Non-exclusive motorcycle lane

G-4. Motorcycle-friendly safety barriers

H. Other facilities

H-1. Reflection mirror

H-2. Lighting

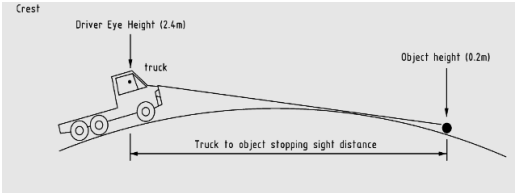
H-3. Variable message sign

H-4. Roadside parking

H-5. Emergency escape ramp

H-6. Emergency telephones

H-7. Sight distance



7.2 Survey in the Asian Highway member countries

A survey was conducted by the ESCAP secretariat in the Asian Highway member countries to assess the prevalence, types and design standards of road safety facilities in the Asian Highway. The survey was sent by the ESCAP secretariat to all 32 Asian Highway member countries in December 2015, and responses were received from 17 member countries.

The purpose of the questionnaire was to develop an understanding of:

- the extent to which the 36 road infrastructure safety facilities (RIFs) identified in the previous section are present on the Asian Highway network
- perception about the effectiveness of the road infrastructure safety facilities if present on the Asian Highway Network.
- the extent to which design standards, guidelines or manuals exist for the road infrastructure safety facilities are present in the member countries
- the reasons that some road infrastructure safety facilities are not present on the Asian Highway network.

The results of the survey are presented in this section.

Highways included in the response

Questionnaire participants were asked to specify which AHs their answers applied to. Table 5 lists the responses.

Table 5: Highways included in the questionnaire responses

Country	Highways
Bangladesh	AH1, AH2, AH41
China	Not specified
DPR Korea	AH1 Pyongyang-Kaesong Completed, Sinuiju-Pyongyang under designing and AH6 Pyongyang-Wonsan Completed, Wonjong-Sonbong-Chongjin-Wonsan-Kosong design completed under construction
Georgia	E60, E117
India	AH1, AH2, AH42, AH43, AH45, AH46, AH47, AH48
I. R. of Iran	AH1, AH2, AH70, AH71, AH72, AH75, AH78, AH8, AH81, AH82
Nepal	AH2, AH42
Republic of Korea	Asian Highway route no 1 (KYONGBU Expressway (No. 1), GUMA Expressway (No. 45), National Highway (NH-No. 1)
Sri Lanka	AH 43
Thailand	AH1, AH2, AH3, AH12, AH13, AH15, AH16, AH18, AH121, AH123

Turkey	AH1-5, AH84 (motorway), AH1, AH5, AH84, AH85, AH87
Viet Nam	Not specified
Tajikistan	AH67
Cambodia	Not specified
Pakistan	Not specified
Philippines	Not specified
Russian Federation	Not specified

Presence of road infrastructure safety facilities (RIFs) on the Asian Highway Network

Questionnaire participants were asked to identify which of the 36 RIFs are present on the AH network in their country. Key findings are:

- all 36 RIFs are used in at least one country
- China, the Russian Federation and Viet Nam use the largest number of the RIFs, with 33, 32 and 32 of the 36 RIFs, respectively
- Nepal uses 3 of the 36 RIFs, which is the fewest by a large margin. The countries with the next fewest numbers are Democratic People's Republic of Korea, Pakistan and Bangladesh, with 12, 14 and 14, respectively
- Nepal, Democratic People's Republic of Korea, Bangladesh, Pakistan, I. R. of Iran and Sri Lanka use less than half of the 36 RIFs
- the most commonly used RIFs are: pedestrian crossings, line marking, sight distance, chevron markers, sidewalk and roadside barriers used in 17, 17, 16, 16, 15 and 15 countries, respectively.
- the least commonly used RIFs are: exclusive motorcycle lane, non-exclusive motorcycle lane and visual traffic calming, present in 1, 1, and 3 countries, respectively.

Figure 9: Number of road infrastructure safety facilities (RIFs) present (%)

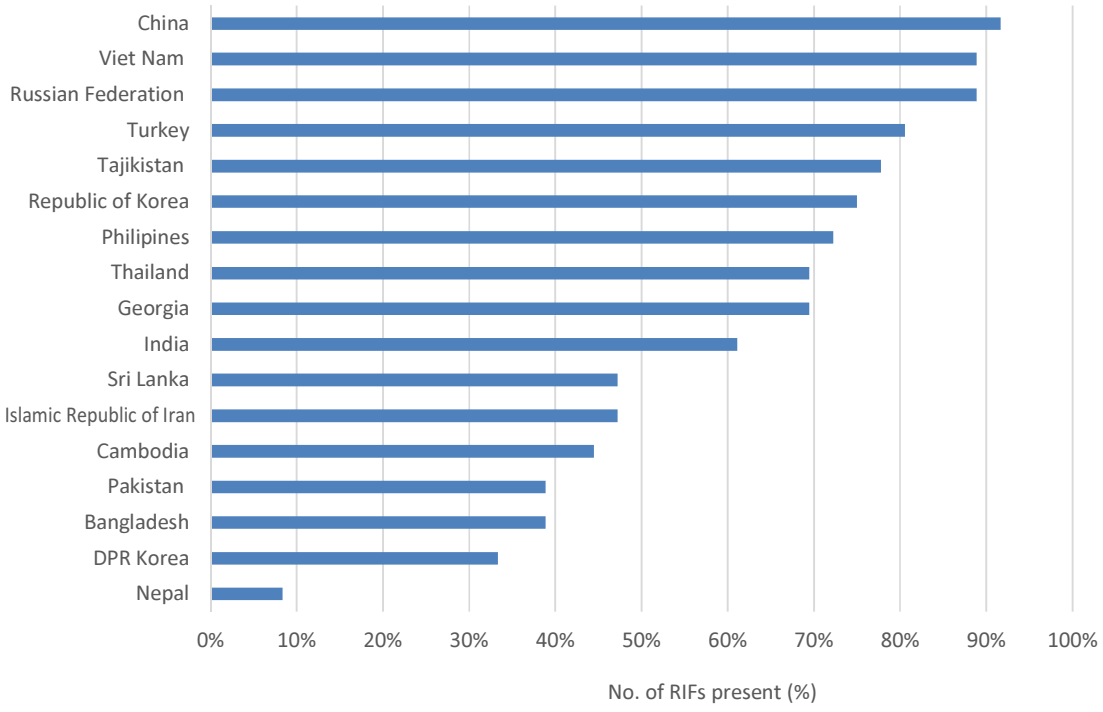
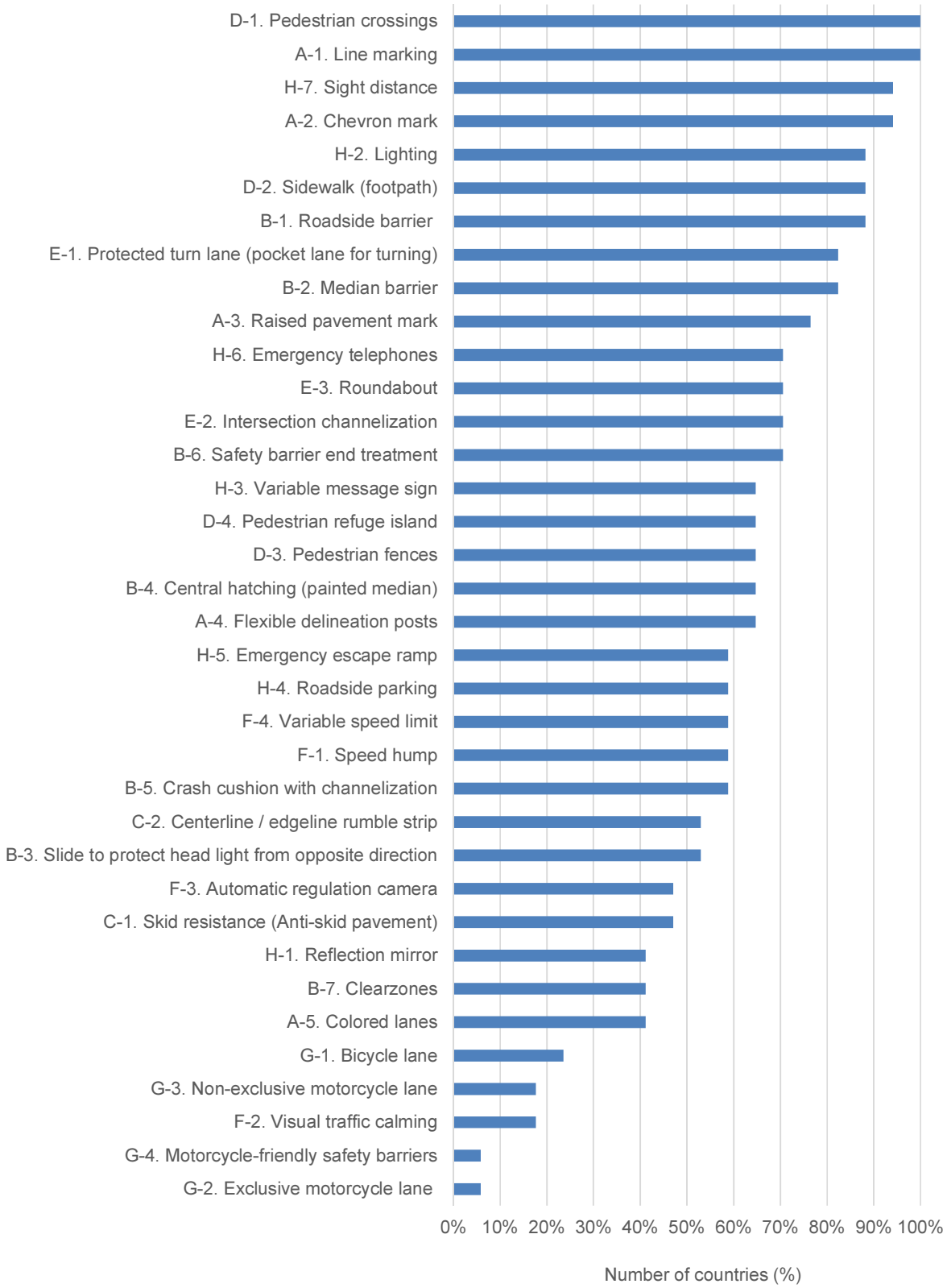


Table 6: Presence of road infrastructure safety facilities (RIFs) per country (X = present)

Road infrastructure facility	Bangladesh	Cambodia	China	DPR Korea	Georgia	India	I. R. of Iran	Nepal	Pakistan	Philippines	Republic of Korea	Russian Federation	Sri Lanka	Tajikistan	Thailand	Turkey	Viet Nam
A-1. Line marking	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
A-2. Chevron mark	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
A-3. Raised pavement mark		X	X		X	X	X		X	X	X	X	X		X	X	X
A-4. Flexible delineation posts	X	X	X	X	X					X	X	X		X	X	X	
A-5. Colored lanes			X							X	X	X			X	X	X
B-1. Roadside barrier	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X
B-2. Median barrier	X		X	X	X	X	X		X	X	X	X		X	X	X	X
B-3. Slide to protect head light from opposite direction			X	X	X	X					X	X		X	X	X	
B-4. Central hatching (painted median)		X	X	X	X	X				X		X		X	X	X	X
B-5. Crash cushion with channelization		X	X		X					X	X	X		X	X	X	X
B-6. Safety barrier end treatment		X	X	X	X					X	X	X	X	X	X	X	X
B-7. Clear zones			X		X						X	X		X		X	X
C-1. Skid resistance (Anti-skid pavement)			X								X	X	X	X	X	X	X
C-2. Centerline / edge line rumble strip		X	X				X		X	X	X	X	X				X
D-1. Pedestrian crossings	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
D-2. Sidewalk (footpath)	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X
D-3. Pedestrian fences			X		X	X				X	X	X	X	X	X	X	X
D-4. Pedestrian refuge island	X		X			X				X	X	X	X	X	X	X	X

Road infrastructure facility	Bangladesh	Cambodia	China	DPR Korea	Georgia	India	I. R. of Iran	Nepal	Pakistan	Philippines	Republic of Korea	Russian Federation	Sri Lanka	Taiikistan	Thailand	Turkey	Viet Nam
E-1. Protected turn lane (pocket lane for turning)	X		X	X	X	X			X	X	X	X	X	X	X	X	X
E-2. Intersection channelization	X		X		X	X				X	X	X	X	X	X	X	X
E-3. Roundabout	X	X	X		X	X			X	X		X	X	X		X	X
F-1. Speed hump	X		X		X	X	X				X	X	X	X			X
F-2. Visual traffic calming			X							X						X	
F-3. Automatic regulation camera			X		X		X				X	X		X		X	X
F-4. Variable speed limit		X	X		X		X		X	X		X		X		X	X
G-1. Bicycle lane			X			X						X			X		
G-2. Exclusive motorcycle lane																	X
G-3. Non-exclusive motorcycle lane		X								X							X
G-4. Motorcycle-friendly safety barriers																	X
H-1. Reflection mirror			X			X	X				X	X		X			X
H-2. Lighting	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X
H-3. Variable message sign			X		X	X	X			X	X	X		X	X	X	X
H-4. Roadside parking			X	X	X	X						X	X	X	X	X	X
H-5. Emergency escape ramp			X				X		X	X	X	X		X	X	X	X
H-6. Emergency telephones			X		X	X	X		X	X	X	X		X	X	X	X
H-7. Sight distance	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X

Figure 10: Number of countries in which road infrastructure safety facilities (RIFs) are present (%)



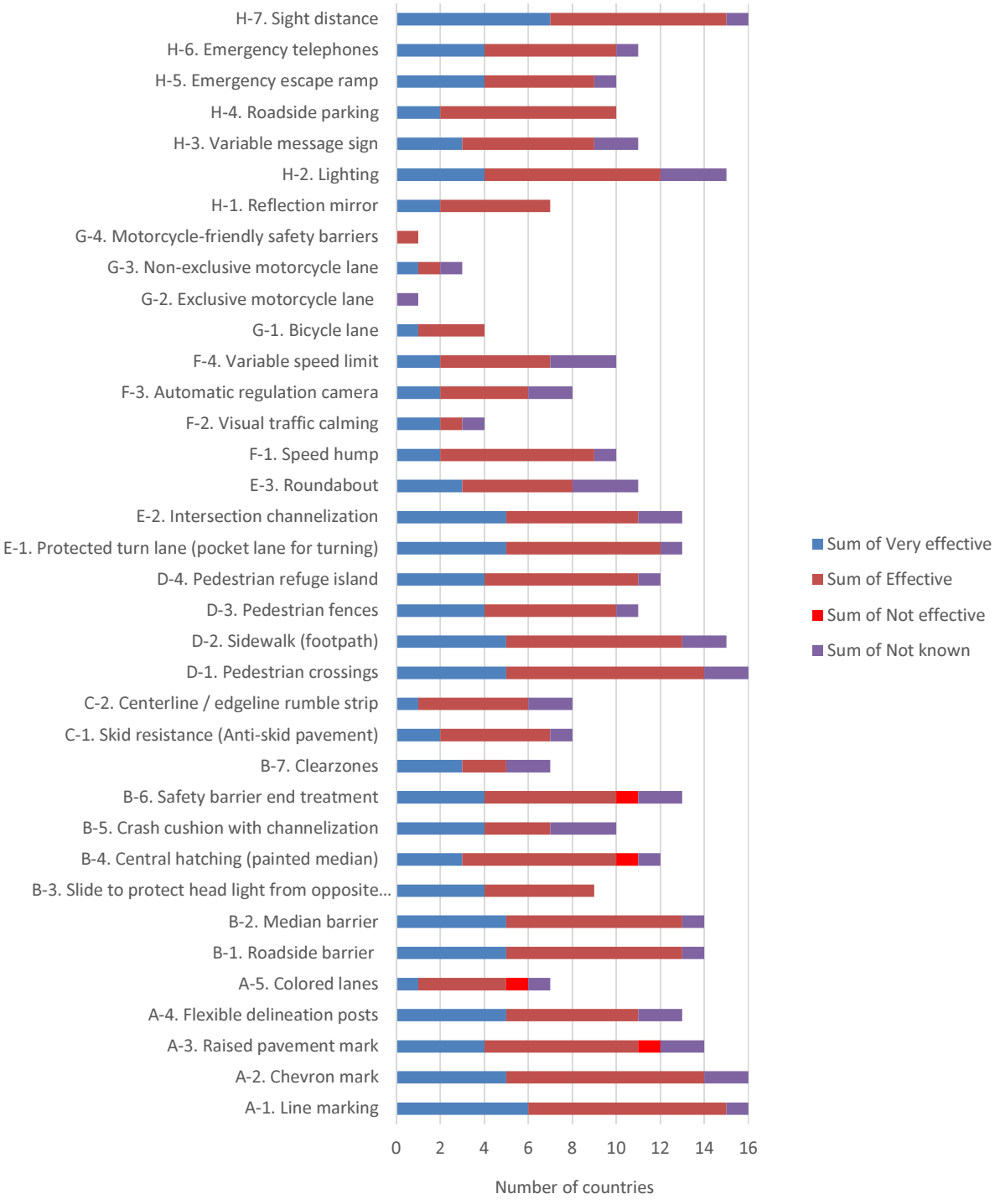
7.3 Perceived effectiveness of road infrastructure safety facilities (RIFs)

In the survey questionnaire, participants were asked to estimate the effectiveness of the RIFs present on the Asian Highway network in their countries, using simple categories of: very effective, effective, not effective and not known. The results are summarized in Figure 11.[23] The key findings are:

- there is a correlation between the extent to which RIFs are present in a country and perceptions about their effectiveness. The RIFs more commonly present (pedestrian crossing, line marking, sight distance, chevron markers, sidewalk) are considered to be very effective or effective
- there is a small number of RIFs that, in a limited number of cases, were considered to be not effective: raised pavement mark, safety barrier end treatment, central hatching and coloured lanes
- in a small number of cases the RIFs effectiveness was not known.

[23] Responses from the Philippines included numerical estimates of effectiveness. These were adjusted to match the questionnaire answer options.

Figure 11: **Perceived effectiveness of RIFs that are present on the AH network ***

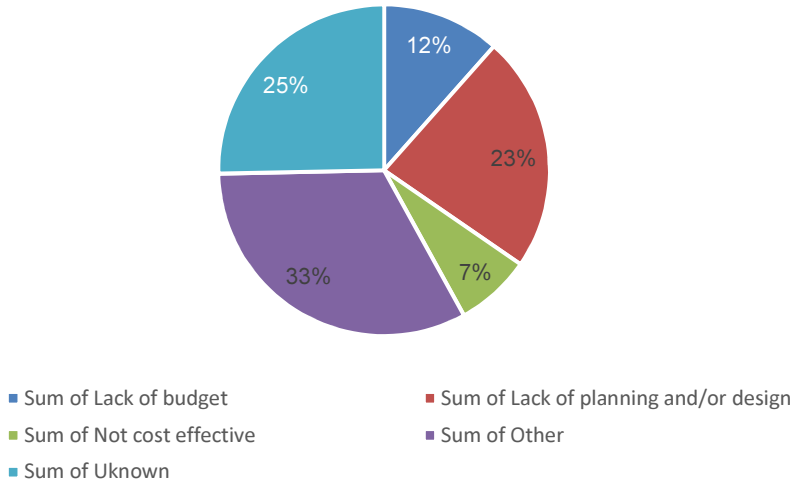


* Samples where a response was provided.

Why certain road infrastructure safety facilities (RIFs) are not used

Questionnaire participants were asked if the facility is not present; are there any specific reasons that it has not been used? The results are summarised in Figure 12. A lack of planning and/or design was cited in about a quarter (25%) of the cases, while a lack of budget was cited in 12% of cases, while the perception that the RIF is not cost effective was cited in 7% of cases. Other reasons were cited in a third (33%) of cases and no reason was provided in the remaining cases.

Figure12: **Reasons RIFs are not present (number of countries, %)**



Reasons that were provided in the 'other' category are summarised in Table 7.

Table 7: 'Other' reasons that an RIF is not present

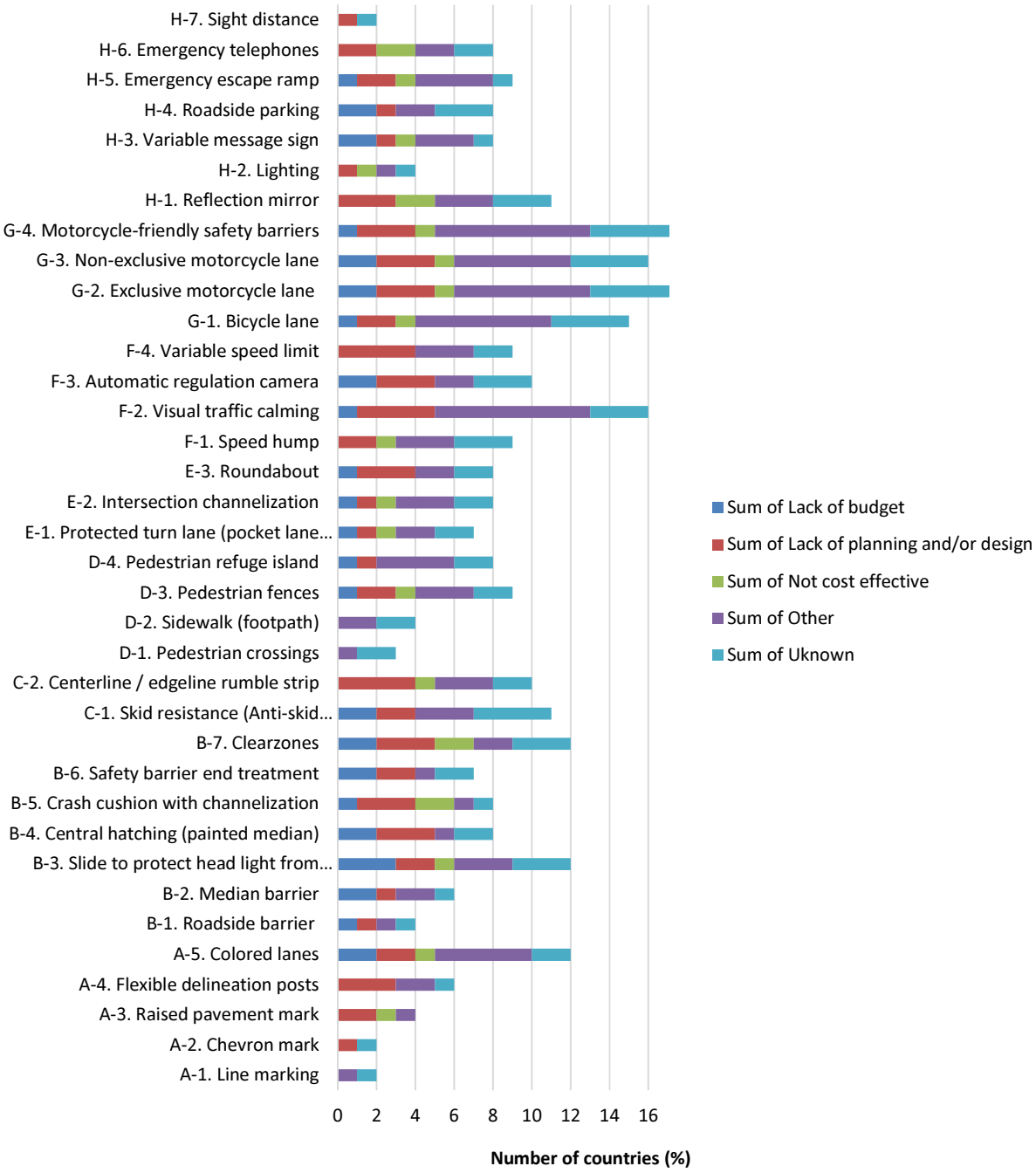
Road infrastructure facility	'Other' reason
C-2. Centerline / edge line rumble strip	Sometimes, it cause some argues relating to noise problem
F-2. Visual traffic calming	Most of highways in route no.1 is consists of primary class. Visual traffic calming have been used in class 2,3 roadway
F-3. Automatic regulation camera	Sometimes, it cause speed deviation among the passing vehicles. And most of cars in the Republic of Korea include automatic camera alarming system. Therefore, it causes sickness
F-4. Variable speed limit	More extensive case-studies should be conducted in advance
G-1. Bicycle lane	There is relatively low volume of bicycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, China.

Road infrastructure facility	'Other' reason
G-2. Exclusive motorcycle lane	There is relatively low volume of motorcycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, Thailand.
G-3. Non-exclusive motorcycle lane	There is relatively low volume of motorcycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, Thailand.
G-4. Motorcycle-friendly safety barriers	There is relatively low volume of motorcycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, Thailand.
H-4. Roadside parking	Most of highways on route no.1 are primary class. So roadside parking is prohibited.
C-2. Centerline / edge line rumble strip	Sometimes, it cause some argues relating to noise problem
F-2. Visual traffic calming	Most of highways in route no.1 is consists of primary class. Visual traffic calming have been used in class 2,3 roadway
F-3. Automatic regulation camera	Sometimes, it cause speed deviation among the passing vehicles. And most of cars in the Republic of Korea include automatic camera alarming system. Therefore, it causes sickness
F-4. Variable speed limit	More extensive case-studies should be conducted in advance
G-1. Bicycle lane	There is relatively low volume of bicycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, china.
G-2. Exclusive motorcycle lane	There is relatively low volume of motorcycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, Thailand.
G-3. Non-exclusive motorcycle lane	There is relatively low volume of motorcycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, Thailand.
G-4. Motorcycle-friendly safety barriers	There is relatively low volume of motorcycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, Thailand.
H-4. Roadside parking	Most of highways in route no.1 is consists of primary class. So roadside parking is prohibited.
C-2. Centerline / edge line rumble strip	Sometimes, it cause some argues relating to noise problem

Road infrastructure facility	'Other' reason
F-2. Visual traffic calming	Most of highways in route no.1 is consists of primary class. Visual traffic calming have been used in class 2,3 roadway
F-3. Automatic regulation camera	Sometimes, it cause speed deviation among the passing vehicles. And most of cars in the Republic of Korea include automatic camera alarming system. Therefore, it causes sickness
F-4. Variable speed limit	More extensive case-studies should be conducted in advance
G-1. Bicycle lane	There is relatively low volume of bicycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, china.
G-2. Exclusive motorcycle lane	There is relatively low volume of motorcycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, Thailand.
G-3. Non-exclusive motorcycle lane	There is relatively low volume of motorcycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, Thailand.
G-4. Motorcycle-friendly safety barriers	There is relatively low volume of motorcycle traffic, so it doesn't seem like urgent problem in the Republic of Korea rather than other countries such as Vietnam, Thailand.
H-4. Roadside parking	Most of highways in route no.1 is consists of primary class. So roadside parking is prohibited.
A-4. Flexible delineation posts	There is another kind
B-3. Slide to protect head light from opposite direction	There is another kind

The results are summarised by RIF in Figure 13.

Figure13: **Reasons an RIF is not present**



Standards for RIF those are present on the Asian Highway Network

Participants were asked whether there are standards, guidelines or manuals that relate to the use of the RIFs present on the AH network and in case there is, participants were asked to name them. The results show that at least one standard, guideline or manual is available for each RIF present on the AH network. In most of the cases standards, guidelines or manuals are available for:

- line marking
- chevron mark
- pedestrian crossings
- roadside barrier
- median barrier
- sidewalk (footpath)
- raised pavement mark
- emergency escape ramp.

The countries that cited the largest number of standards, guidelines or manuals are: Thailand, Republic of Korea and Turkey. The countries that cited the fewest number of standards, guidelines or manuals are: Islamic Republic of Iran, the Philippines and Nepal. Annex C lists all standards, guidelines and/or manuals cites by RIF and country.

7.4 Discussions and conclusions on the survey

The questionnaire results received from 17 countries show that all the 36 RIFs are used in at least one country. It is unsurprising that the RIFs most commonly present on the AHs are also those that are perceived to be most effective. These include: pedestrian crossing, line marking, sight distance, chevron markers, side walk and roadside safety barriers. The countries that use the largest number of the RIFs are China, the Russian Federation and Viet Nam.

The results suggest that there is potential to promote the use of a broader range of RIF on the AH network; just 10 of the countries use more than half of the 36 RIFs. For example, centreline and edge line rumble strips are present on AHs in just over half of the sample countries, even though empirical evidence shows that this type of treatment can be very effective on higher-speed roads. Perhaps surprisingly, RIFs that are specific to motorcycle safety, such as exclusive motorcycle lane, non-exclusive motorcycle lane and motorcycle-friendly safety barriers are among the least used RIFs on the AH network, despite many countries in the ESCAP region having relatively high motorcycle volumes.

The results also suggest that a rapid take up of internationally well-used RIFs in particular countries may be needed. For example, Nepal reported using just three of the 36 RIFs, even though the roads in that country are very often steep with sharp bends and are known to be high-risk. Notably though, Nepal did report that a large number of the RIFs are now being included in road designs.

The questionnaire identifies a number of reasons that particular RIFs are not used, including lack of planning and/or design (23%), lack of budget (12%), not cost effective (7%) and other reasons (33%). Other reasons include issues relating to the vehicle mix in a country (for example, there are relatively few motorcyclists in the Republic of Korea) and possible side effects, such as noise caused by rumble strips. Apart from developing a regional standard that supports design and implementation of a broader range of RIFs, these questionnaire results suggest that case studies to support the use of each RIF and training on use of each RIF may be helpful in removing perceived barriers to their use. This training could also address assist in ensuring that RIFs which are reportedly commonly present on the AH network are installed according to best practice and identifying ways in which to address localised challenges. For example, the result show that pedestrian crossings are widely perceived to be effective, yet in practice there is an extensive problem with drivers failing to yield for pedestrians on crossings and therefore failing to comply with the law. Issues of cost effectiveness and availability of funding are also key barriers to the use of some RIFs, and therefore need to be addressed.

The questionnaire responses also provided an extensive list of standards, guidelines and/or manuals related to the use of the RIFs, and therefore provided a useful resource for the development of road safety facility infrastructure standards for the ESCAP region.

Overall, the results of the questionnaire, when taken into account along with empirical evidence and best practices, are useful in the development of road safety facility infrastructure standards.

8. Star Rating Testing for the Asian Highway Design Standards

The iRAP methodology was used to illustrate how relative risk levels for vehicle occupants, motorcyclists, pedestrians and bicyclists would change if RIFs were added to the standard. As part of the context it is mentionable that the Note[24] by the Secretary-General of the United Nations prepared for the seventieth session of the General Assembly on "improving global road safety" included a recommendation to improve infrastructure, including by targeting the highest volume 10 per cent of existing roads and set appropriate road infrastructure star rating targets for all relevant road users and adopting minimum three-star standards and road safety audits for all new road constructions.

One of the goals of this study was therefore to test whether the RIFs identified could be used to improve the AH safety rating to at least three-stars - for all road users.

8.1 iRAP Star Ratings

iRAP Star Ratings are based on road infrastructure features and the degree to which they impact the likelihood and severity of road crashes. The focus is on the features which influence the most common and severe types of crash on roads for motor vehicles, motorcyclists, pedestrians and bicyclists. They provide a simple and objective measure of the relative level of risk associated with road infrastructure for an individual road user. 5-star (green) roads have the lowest level of risk, while 1-star (black) roads are the highest level of risk.

The Star Ratings are based on Star Rating Scores (SRS). The iRAP models are used to calculate an SRS at 100 metre intervals for each of the road user types, based on relative risk factors for each of the road attributes. The scores are developed by combining relative risk factors using a multiplicative model. A doubling of the SRS represents a doubling of the risk of death and serious injury. More information on the risk factors used within the model can be found at http://irap.org/en/about-irap-3/methodology.

[24] General Assembly Note A/70/386, page 19 para (g).

8.2 Analysis approach for the Star Rating

Scenario testing was conducted for each of the highway and terrain classifications specified in *Annex II Asian Highway Classification and Design Standards* of the *Intergovernmental Agreement on the Asian Highway Network* (referred to herein as the AH Standard).[25] Separate testing was conducted for vehicle occupants, motorcyclists, pedestrians and bicyclists.

Road attributes were included in a synthesised dataset and analysed using the iRAP software *ViDA*. Each scenario was modelled for a 3km length of road comprised of 30 x 100 metre segments. Road attributes for each 100 metre segment were recorded in a single row of an Excel file. Road attributes appearing at intermittent intervals on the network (such as intersections) were inserted in the dataset at the appropriate frequency.

Adding attributes to the baseline scenario in the synthesised data-set enabled the individual influence of the different road characteristics on the Star Ratings to be assessed in a systematic manner. Different scenarios were progressively compiled for the four highway classifications and, within each highway classification; the influence of the RIFs within the four terrains was assessed.
Using the Star Rating Scores (SRS), it was then straightforward to illustrate general patterns in matrices of the influence of the RIFs on the Star Rating.

This process can be repeated using the publicly-available iRAP Star Rating Demonstrator, which is available at http://vida.irap.org. Specifications on iRAP road attribute coding are detailed in *Star Ratings and Investment Plans: Coding Manual*.[26]

Star Rating Bands

iRAP Star Ratings are determined by assigning Star Rating Scores (SRS) to the bands as shown in the table below. Separate bands are used for motorised road users (vehicle occupants and motorcyclists), bicyclists and pedestrians because their scores are calculated using different equations. That is, motorised road user scores are based on head-on, run-off road and intersection crashes; pedestrian scores are based on walking along and across the road crashes; and bicyclist scores are based on riding along the road and intersections crashes. More information about the Star Rating bands is available in: iRAP Methodology Fact Sheet #7: Star Rating bands.[27]

[25] Available at: http://www.unescap.org/our-work/transport/asian-highway
[26] Available for download at: http://irap.org/en/about-irap-3/specifications.
[27] Available for download at: http://irap.org/en/about-irap-3/methodology.

Table 8: Star Rating bands and colours

Star Rating	Star Rating Score				
	Vehicle occupants and motorcyclists	Bicyclists	Pedestrians		
			Total	Along	Crossing
5	0 to < 2.5	0 to < 5	0 to < 5	0 to < 0.2	0 to < 4.8
4	2.5 to < 5	5 to < 10	5 to < 15	0.2 to < 1	4.8 to < 14
3	5 to < 12.5	10 to < 30	15 to < 40	1 to < 7.5	14 to < 32.5
2	12.5 to < 22.5	30 to < 60	40 to < 90	7.5 to < 15	32.5 to < 75
1	22.5+	60+	90+	15+	75+

8.3 Existing Asian Highway Network design standards and star ratings

The existing AH design standard, which sets minimum requirements for a limited number of road attributes, is summarised in Table 10. The standard includes four highway classifications (Primary, Class I, Class II and Class III) and, for each highway class, four terrain classifications (Level, Rolling, Mountainous and Steep).

Baseline Assumptions

In order to produce star ratings for the existing AH design standards, a number of assumptions were made about the existing AH design standards. For the purposes of the modelling, key assumptions include that:

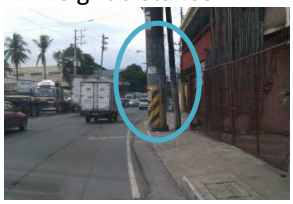
- Traffic volumes increase by 2,500 vehicles per day (vpd) per lane for each class:
    - Class III roads were assumed to carry 2,500 vpd per lane (or a total of 5,000 vpd for two lanes)
    - Class II roads were assumed to carry 5,000 vpd per lane (or a total of 10,000 vpd for two lanes)
    - Class I roads were assumed to carry 7,500 vpd per lane (or a total of 30,000 vpd for four lanes)
    - Primary roads were assumed to carry 10,000 vpd per lane (or a total of 40,000 vpd for four lanes).

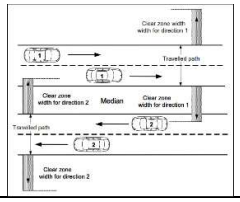
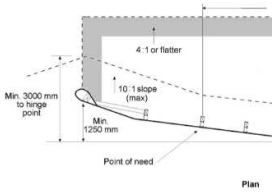
- Operating speeds are equal to the design speeds (this topic is discussed further in the discussion and conclusion section of the report).
- Roadsides hazards are present and Mountainous and Steep roads have short sections where cliffs present.

- Curves become more frequent and tighter (smaller radius) moving from Level terrain to Steep terrain.
- All intersections on the Primary highways are grade separated, while intersections are four-leg unsignalised on the other highway classes. Intersections become increasingly frequent moving from Primary to Class III roads.
- Pedestrians, bicyclists and motorcyclists are present on all highway classes (this topic is discussed further in the discussion and conclusion section of the report), and the number of locations that pedestrians cross the highway increase moving from Primary to Class III roads.

8.4 Scenarios considered

A series of scenarios were established by adding RIFs to the baseline existing AH standard, as described below. The RIFs were selected from an original list of 36 options identified in Chapter 7.

Scenarios	Road Infrastructure Attributes	
Adequate delineation is provided on all highway and terrain classes, through the application of line marking, chevron markers, raised reflectorized pavement markers and flexible delineator posts.	A-1. Line marking  A-3. Raised reflectorized pavement markers 	A-2. Chevron markers  A-4. Flexible delineator posts 
Shoulder rumble strips are provided on all Primary class highways, all higher speed Class I highways (100km/h and 80km/h) and on curves on other Class I, II and III highways.	C-2. Centerline / edge line rumble strips 	
Sight distances at intersections and pedestrian crossings are made adequate (that is, there would be no obstructions).	H-7. Sight distance 	

Roadside hazards are managed, especially on Primary class highways, higher speed Class I highways (100km/h and 80km/h) and on curves on other Class I, II and III highways, through the use of clear zones and safety barriers.	B-1. Roadside barrier  B-7. Clear zones 	B-6. Safety barrier end treatment 
Median safety barriers are provided on all Primary class highways, all higher speed Class I highways (100km/h and 80km/h), other Class I roads have a 1-5m wide median island, wide centerline treatment is provided on higher speed (80km/h) Class II highways, and rumble strips (audio tactile lines) are provided on curves of other highways.	B-2. Median barrier 	B-5. Crash cushion with channelization 
Street lighting is provided at intersections, at pedestrian crossings and where bicyclists are present on all highway classes.	H-2. Lighting 	
Protected turn lanes are provided at at-grade intersections (note that it is assumed that Primary highways have grade-separated intersections).	E-2. Protected turn lanes 	
Islands are provided at at-grade intersections to channelize turning vehicles (note that it is assumed that Primary highways have grade-separated intersections).	E-2. Intersection channelization 	
A separate scenario was tested whereby roundabouts are provided at at-grade intersections.	E-3. Roundabout 	

Where pedestrians are present, sidewalks with a physical barrier are provided on all Primary class highways, all higher speed Class I highways (100km/h and 80km/h), and paved sidewalks are provided on all other classes of highway.	D-2. Paved sidewalk (with barrier) 	D-2. Paved sidewalk 
Where pedestrians are present, grade separated crossings are provided on Primary highways, signalized crossings are provided on Class I highways and marked crossings with refuge islands are provided on Class II and Class III highways.	D-1a. Grade separated  D-4. Pedestrian refuge island 	D-1b. Marked crossing 
Where bicyclists are present, off-road bicycle paths are provided on Primary highways and high speed (100km/h) Class I highways and marked on-road lanes are provided on other Class I and Class II highways (noting that Class III roads have paved shoulders).	G-1a. Off-road bicycle lane 	G-1b. On-road bicycle lane 
Where motorcycle volumes are high, exclusive lanes are provided on Primary Highways and non-exclusive lanes are provided on other classes of highway.	G-2. Exclusive motorcycle lane 	G-3. Non exclusive motorcycle lane 
Visual traffic calming is provided at curves and intersections on Primary highways and high speed (100km/h) Class I highways, visual traffic calming and/or speed humps are provided on other classes of highway at curves, intersections and pedestrian crossings.	F-1. Speed bump 	F-2. Visual traffic calming 

Table 10: Summary of existing Asian Highway network design standards

Highway classification	PRIMARY				CLASS I				CLASS II				CLASS III			
Terrain classification	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**
Design speed (km/h)	120	100	80	60	100	80	50	50	80	60	50	40	60	50	40	30
Right of way (m)	50				40				40				30			
Lane (m)	3.5				3.5				3.5				3.0 (3.25)			
Shoulder (m)	3		2.5		3		2.5				2		1.5 (2.0)		0.75 (1.5)	
Median strip (m)	4		3				2.5		None							
Min. radii of horizontal curve (m)	520 (1000)	350 (600)	210 (350)	115 (160)	350 (600)	210 (350)	80 (110)	210	115	80	50	115	80		50	30
Pavement slope (%)	2												2 - 5			
Shoulder slope (%)	3 - 6															
Type of pavement	Asphalt/cement concrete												Dbl. bituminous treatment			
Max. superelevation (%)	10															
Max. vertical grade (%)	4	5	6	7	4	5	6	7	4	5	6	7	4	5	6	7
Structure loading (minimum)	HS20-44															

L = level, R = rolling, M = mountainous, S = steep.

Table11: Summary of baseline assumptions

Highway classification	**PRIMARY**				**CLASS I**				**CLASS II**				**CLASS III**			
Terrain classification	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**
AADT (vehicles per day)	40000				30000				10000				5000			
Operating speed = design speed (km/h)	120	100	80	60	100	80	50	50	80	60	50	40	60	50	40	30
No. lanes	4.0								2.0							
Lane width (m)	3.5												3.0			
Shoulder - unpaved (m)	3		2.5		3		2.5			2			1.5		0.75	
Roadsides	Trees / poles or other rigid objects 1-5m from edge, cliffs on M (100m per km) and S (200m per km) roads															
Curves	Range from 1000m to desirable minimum radii															
Curve frequency (per km)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Median (m)	4		3				2.5		None							
Intersections	Grade separated				4-leg unsignalised											
Intersection frequency (per km)	0.3	0.3	0.3	0.3	0.7	0.7	0.7	0.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Pedestrians	Present															
Pedestrians crossing demand points (per km)	0.7	0.7	0.7	0.7	1.3	1.3	1.3	1.3	1.7	1.7	1.7	1.7	2.0	2.0	2.0	2.0
Pedestrian facilities	None															
Bicyclists	Present															
Bicyclist facilities	None															
Motorcyclists	Present															
Motorcyclist facilities	None															

L = level, R = rolling, M = mountainous, S = steep.

Table12: Summary of additional road infrastructure facilities

Highway classification	PRIMARY				CLASS I				CLASS II				CLASS III			
Terrain classification	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**
Delineation	Good line marking (A-1), raised reflectorized pavement markers (A-3) and flexible delineator posts (A-4), and chevron markers on curves (A-2)															
Paved shoulder (m)	3		2.5		3				2.5				2		1.5	0.75
Rumble strips	Shoulder rumble strips (C-2)								Shoulder rumble strips at curves (C-2)							
Sight distance	Adequate sight distance (H-7)															
Roadsides	Clear zone (5-10m) (B-7) or safety barrier (B-1) with safe end treatment (B-6)								Clear zone (5-10m) (B-7) or safety barrier (B-1) with safe end treatment (B-6) at curves							
Median treatment	Median safety barrier (B-2) with safe end treatment (B-5, B-6)				Island 1-5m wide				Wide CL (B-4)				Centreline (rumble strips at curves) (C-2)			
Lighting	Street lighting (H-2) at intersections, at pedestrian crossings and where bicyclists are present															
Intersection protected turn lanes	N/A				Protected turning pockets at intersections (E-1)											
Intersection channelization	N/A				Islands at intersections to channelize turning vehicles (E-2)											
Roundabout	N/A				Roundabouts (E-3)											
Pedestrian sidewalk	Sidewalk (D-2) with physical barrier where pedestrians are present								Paved sidewalk (D-2) where pedestrians are present							
Pedestrian crossings	Grade separated (D-1)				Signalised (D-1)				Marked crossing (D-1) with refuge island (D-4)							
Bicycle lanes	Off-road path (G-1a) where bicyclists are present								Marked on road lanes (G-1b) where bicyclists are present				Shoulder			
Motorcycle lanes	Exclusive lanes (G-2) where motorcycle volumes are high								Non-exclusive motorcycle lanes (G-3) where motorcycle volumes are high							
Traffic calming	Visual traffic calming (F-2) at curves and intersections								Visual traffic calming (F-2) and/or speed humps (F-1) at curves, intersections and pedestrian crossings							

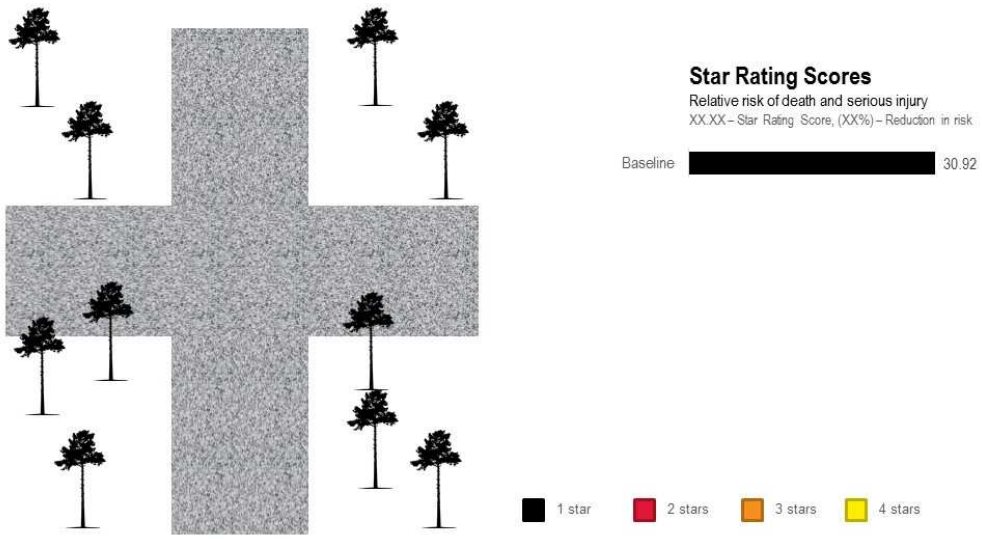
Road Infrastructure Facilities (RIFs) Not Included in the Analysis

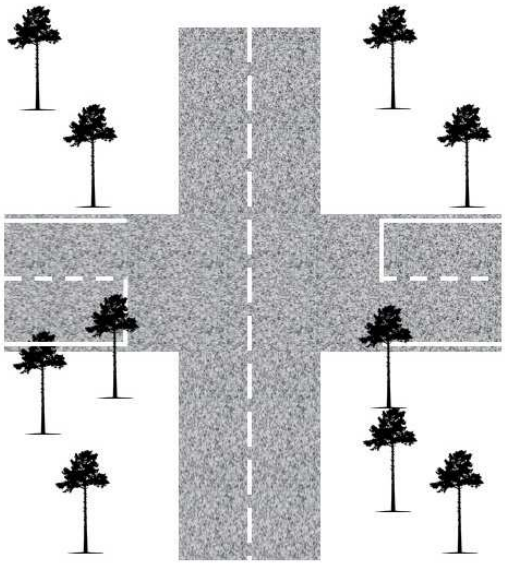
Earlier it was stated that the RIFs used in this study were selected from a list of 36 previously identified RIFs. Some of the RIFs in that list were not included in this study. Although these RIFs may have some safety benefit if used on the AH network, they we excluded from this study either because they are not included in the iRAP model or are not easily modelled in this type of study. Generally speaking, RIFs are included in the iRAP model when there is strong empirical evidence that they have an effect on risk of death and serious injury and when that effect is bigger than 10 per cent. The RIFs not included in this study are: coloured lanes (A-5), slide to protect head light from opposite direction (B-3), skid resistance (C-1), variable speed limit (F-4), reflection mirror (H-1), variable message sign (H-3), roadside parking (H4), emergency escape ramp (H-5) and emergency telephones (H-6).

8.5 Results of the Star Rating Testing

The following images provide an illustrated example of the Star Rating testing, for a Class II highway in level terrain. The images illustrate the RIFs as they are applied to the highway and the effect that they have on the Star Rating Scores.

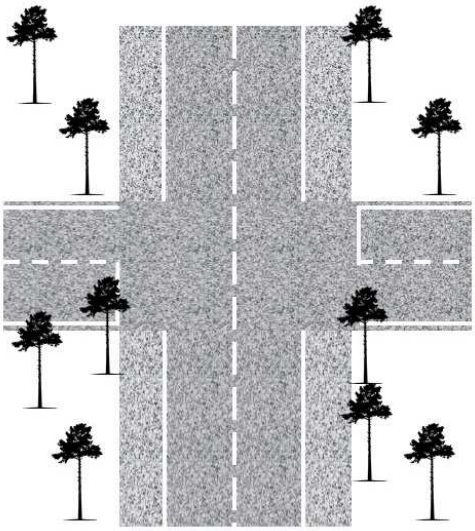
Figure 14: Illustrated example of addition of RIFs to a Class II highway





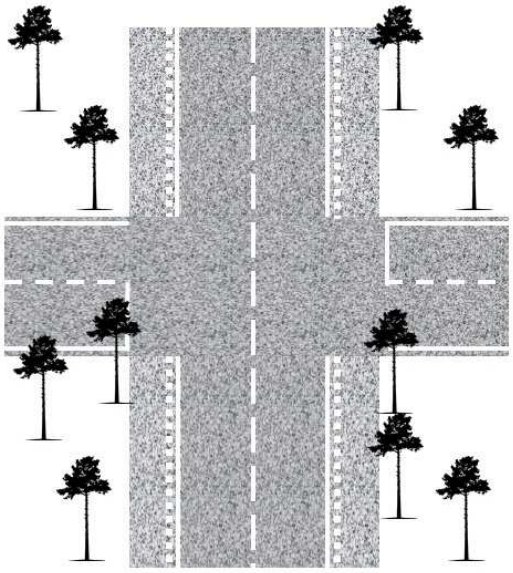

Star Rating Scores
Relative risk of death and serious injury
XX.XX – Star Rating Score, (XX%) – Reduction in risk
Baseline
30.92
+ delineation
26.13 (16%)


1 star
2 stars
3 stars
4 stars



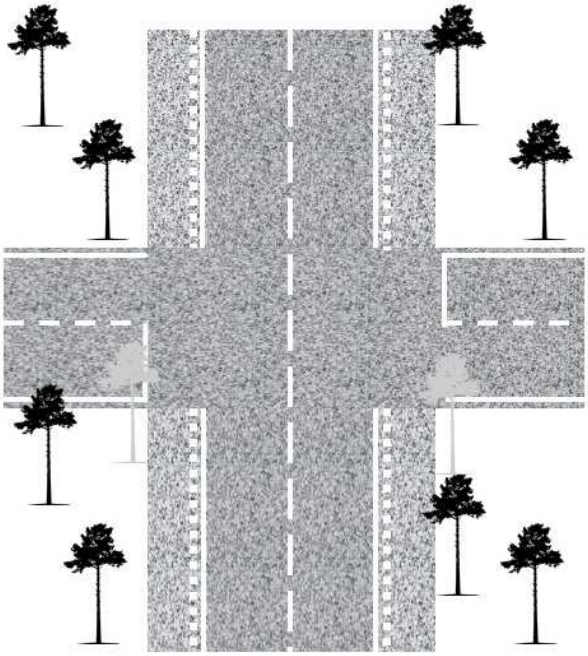

Star Rating Scores
Relative risk of death and serious injury
XX.XX – Star Rating Score, (XX%) – Reduction in risk
Baseline
30.92
+ delineation
26.13 (16%)
+ paved shoulder
21.72 (17%)


1 star
2 stars
3 stars
4 stars



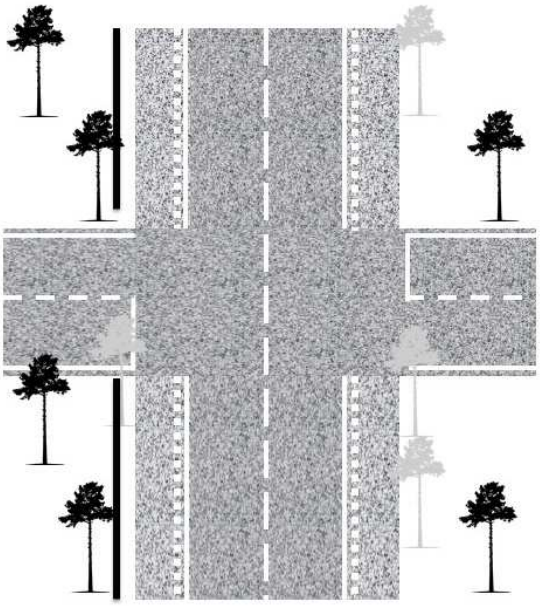

Star Rating Scores
Relative risk of death and serious injury
XX.XX – Star Rating Score, (XX%) – Reduction in risk
Baseline
30.92
+ delineation
26.13 (16%)
+ paved shoulder
21.72 (17%)
+ rumble strips
18.76 (14%)

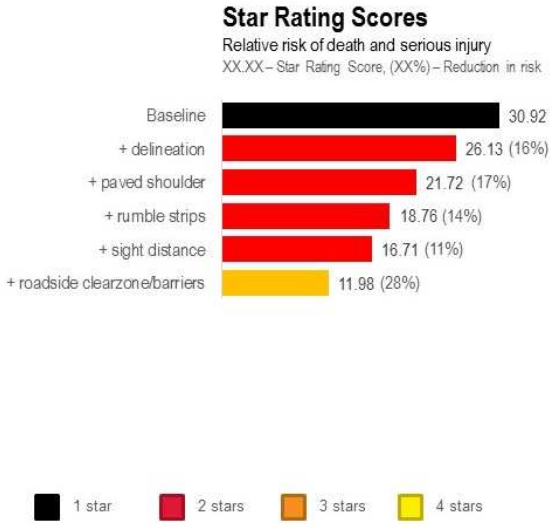

1 star
2 stars
3 stars
4 stars

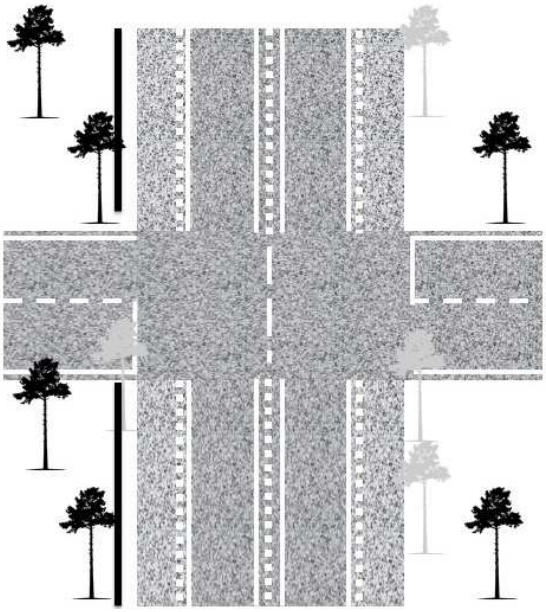


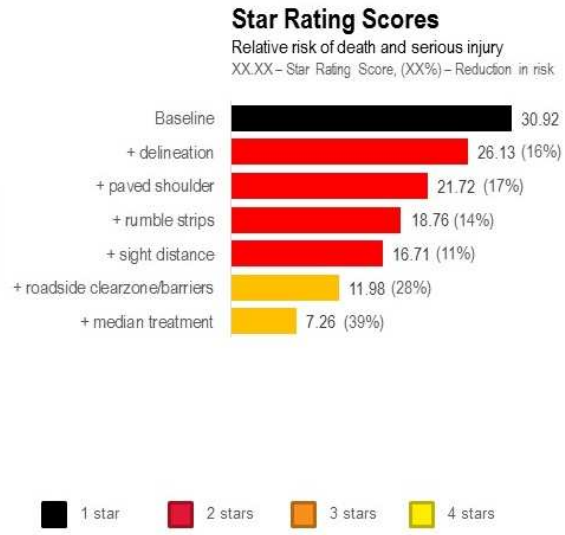

Star Rating Scores
Relative risk of death and serious injury
XX.XX – Star Rating Score, (XX%) – Reduction in risk
Baseline
30.92
+ delineation
26.13 (16%)
+ paved shoulder
21.72 (17%)
+ rumble strips
18.76 (14%)
+ sight distance
16.71 (11%)

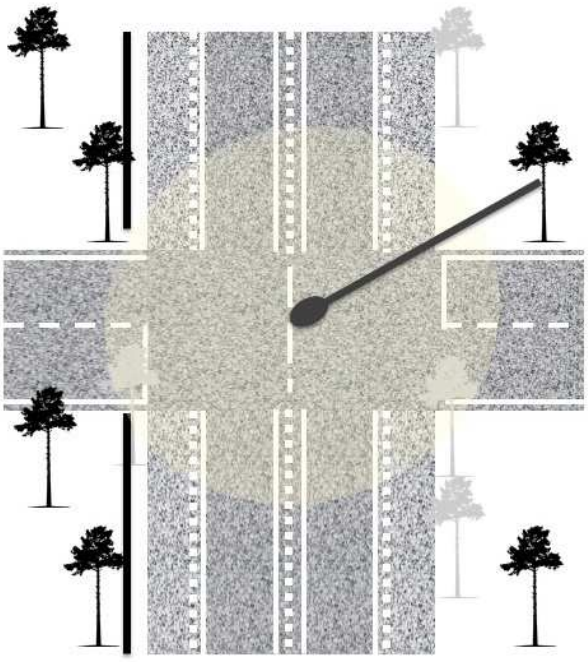

1 star
2 stars
3 stars
4 stars

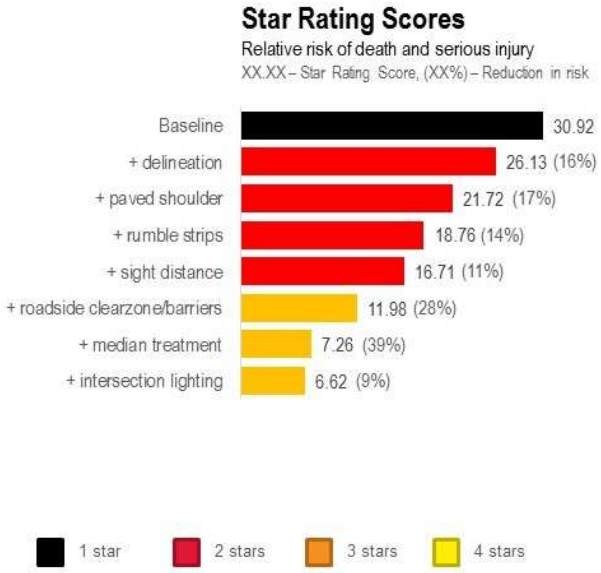


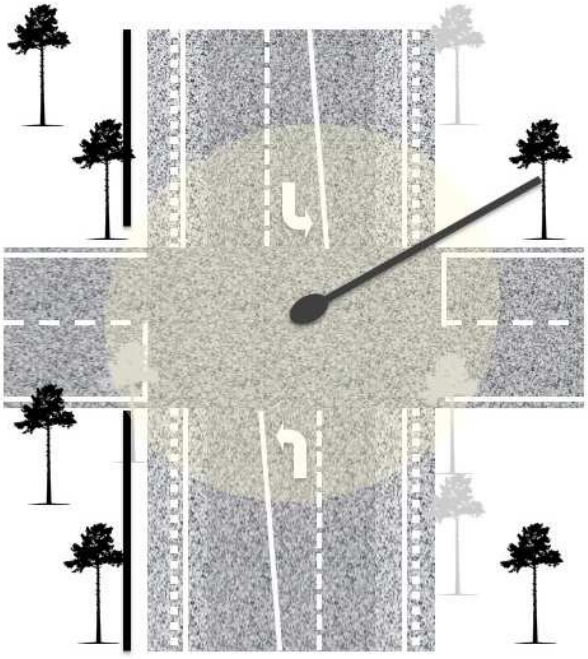

Star Rating Scores
Relative risk of death and serious injury
XX.XX – Star Rating Score, (XX%) – Reduction in risk
Baseline
30.92
+ delineation
26.13 (16%)
+ paved shoulder
21.72 (17%)
+ rumble strips
18.76 (14%)
+ sight distance
16.71 (11%)
+ roadside clearzone/barriers
11.98 (28%)
1 star
2 stars
3 stars
4 stars

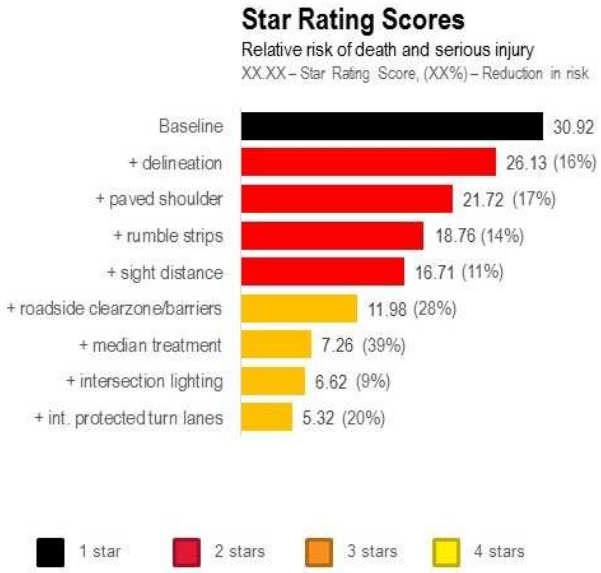


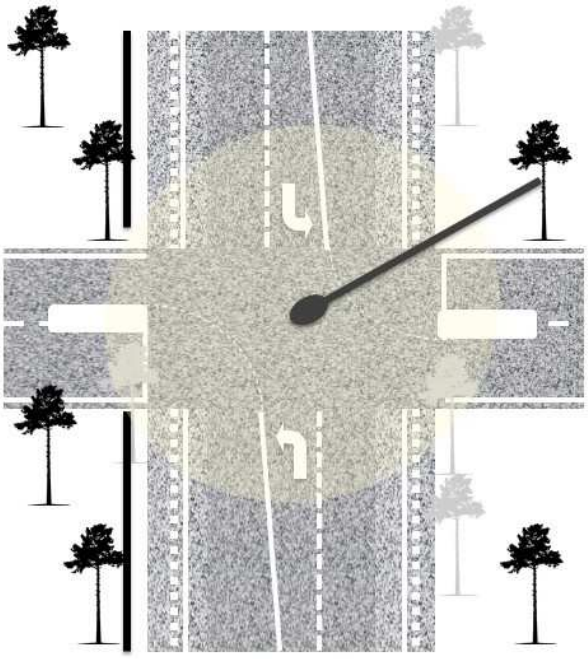

Star Rating Scores
Relative risk of death and serious injury
XX.XX – Star Rating Score, (XX%) – Reduction in risk
Baseline
30.92
+ delineation
26.13 (16%)
+ paved shoulder
21.72 (17%)
+ rumble strips
18.76 (14%)
+ sight distance
16.71 (11%)
+ roadside clearzone/barriers
11.98 (28%)
+ median treatment
7.26 (39%)
1 star
2 stars
3 stars
4 stars

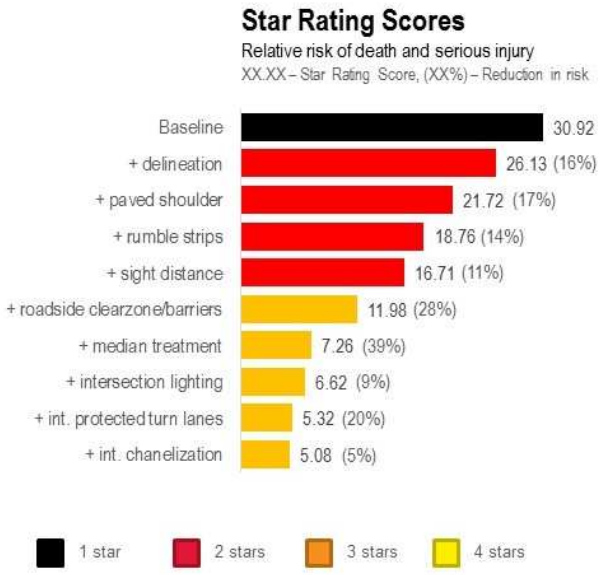


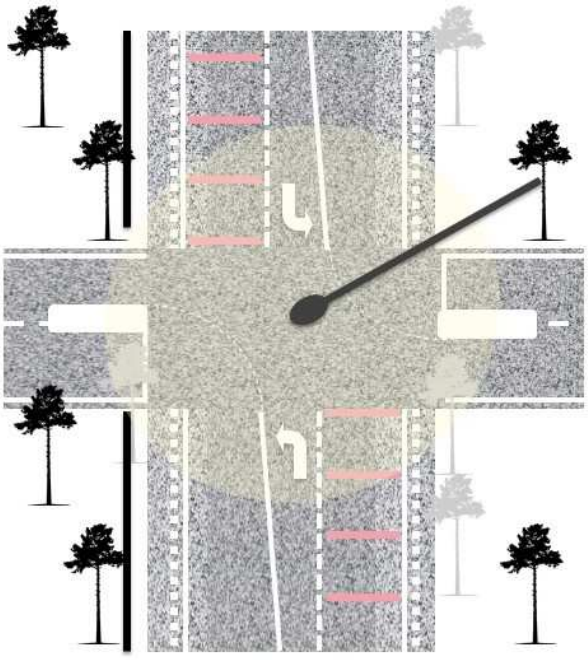

Star Rating Scores
Relative risk of death and serious injury
XX.XX – Star Rating Score, (XX%) – Reduction in risk
Baseline 30.92
+ delineation 26.13 (16%)
+ paved shoulder 21.72 (17%)
+ rumble strips 18.76 (14%)
+ sight distance 16.71 (11%)
+ roadside clearzone/barriers 11.98 (28%)
+ median treatment 7.26 (39%)
+ intersection lighting 6.62 (9%)
1 star
2 stars
3 stars
4 stars

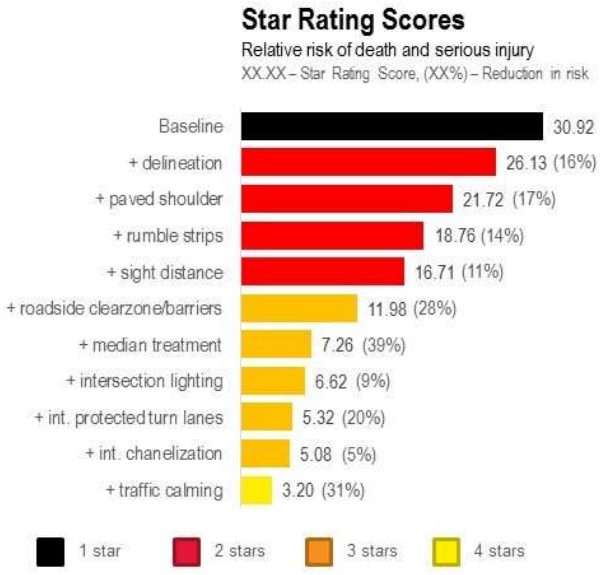



Star Rating Scores
Relative risk of death and serious injury
XX.XX – Star Rating Score, (XX%) – Reduction in risk
Baseline 30.92
+ delineation 26.13 (16%)
+ paved shoulder 21.72 (17%)
+ rumble strips 18.76 (14%)
+ sight distance 16.71 (11%)
+ roadside clearzone/barriers 11.98 (28%)
+ median treatment 7.26 (39%)
+ intersection lighting 6.62 (9%)
+ int. protected turn lanes 5.32 (20%)
1 star
2 stars
3 stars
4 stars









8.6 Results by road user type

The results for vehicle occupants, motorcyclists, pedestrians and bicyclists are shown in Tables 11, 12, 13 and 14 respectively. Key points about the results include:

- With some exceptions, the baseline risk scores for highways are in the high-risk are in the high risk 1- and 2-star ranges. This reflects a combination of very limited infrastructure provision that is specified in the AH design standards and, especially in the Level and Rolling terrain classes, relatively high speeds.

- For each of the scenarios, the risk scores tend to improve when moving from Primary to Class III highways and from Level to Steep terrain. This is largely a function of speed. For example, the speed for a Primary Level highway is 120km/h while the speed for a Primary Steep highway is just 60km/h. In the Class III category, speeds range from 60km/h to 30km/h. The way in which speed affects risk is discussed in a subsequent section of the report.
- For each of the road user types, the risk scores for Class II Steep highways are higher than Class II Mountainous highways, which are the opposite of the case for Primary, Class I and Class III roads. This reflects the fact that speeds are the same for Class II Mountainous and Steep highways, but it is assumed that Steep highways have more sharp curves and more hazardous roadsides.
- Without exception, the addition of RIFs results in reductions in risk. In terms of risk reductions, the following RIFs are among the most effective:
  - Off-road bicycle paths.
  - Fences to prevent pedestrians crossing.
  - Sidewalks.
  - Pedestrian crossings.
  - Median treatments.
  - Roadside clear zones / safety barriers.
  - Roundabouts (compared with unsignalized 4-leg intersections).
- At least a 3-star rating was achieved for each of the road user types. In the case of Class II and Class III highways, which have very low design speeds, either the baseline scenario achieves at least 3-stars or 3-stars can be achieved with the application of one or a few RIFs, such as delineation. For the higher speed roads, significantly more RIFs are required in order to achieve a 3-star or better rating. This is especially the case for vulnerable road users.

Table 11: Vehicle occupant Star Ratings

Highway classification	Primary				Class I				Class II				Class III			
Terrain classification	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**
Baseline	42.26	27.09	19.35	13.30	30.92	19.57	7.75	10.73	22.70	13.01	11.57	9.30	10.55	8.39	7.64	6.10
+ delineation	33.96	21.05	14.26	9.36	26.13	15.70	5.76	7.71	18.96	10.20	8.54	6.60	8.74	6.52	5.54	4.24
+ paved shoulder	26.33	16.32	11.03	7.23	21.72	12.91	4.64	6.13	16.75	8.90	7.60	5.76	7.55	5.56	5.33	4.06
+ rumble strips	21.22	13.14	8.87	5.80	18.76	11.04	4.12	5.29	15.75	8.42	6.89	5.05	7.33	5.21	4.70	3.43
+ sight distance	20.99	13.01	8.80	5.78	16.71	9.98	3.87	5.03	14.16	7.76	6.50	4.85	6.66	4.83	4.50	3.35
+ roadside clear zone/barriers	12.81	7.93	5.63	3.97	11.98	7.00	3.25	4.08	13.50	7.00	5.73	4.30	6.31	4.27	3.92	3.01
+ median treatment	4.64	2.86	1.75	0.97	7.26	4.01	1.64	1.70	10.12	5.25	3.44	1.94	4.75	3.04	1.85	0.85
+ intersection lighting	4.57	2.82	1.73	0.96	6.62	3.68	1.56	1.62	9.63	5.04	3.32	1.87	4.54	2.92	1.79	0.82
+ int. protected turn lanes	Not applicable				5.32	3.01	1.40	1.46	8.63	4.62	3.08	1.75	4.12	2.67	1.67	0.77
+ int. channelization					5.08	2.89	1.37	1.43	8.51	4.57	3.04	1.73	4.07	2.64	1.65	0.76
+ traffic calming	4.47	2.76	1.70	0.95	4.53	2.61	1.30	1.36	8.08	4.39	2.94	1.68	3.89	2.54	1.60	0.74
+ roundabout (instead of regular int. and traffic calming)	Not applicable				3.20	1.92	1.13	1.19	6.99	3.93	2.68	1.54	3.43	2.27	1.46	0.68

Keys:

5-star
4-star
3-star
2-star
1-star
Not applicable

Table12: Motorcyclist Star Ratings

Highway classification	Primary				Class I				Class II				Class III			
Terrain classification	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**
Baseline	57.44	36.99	25.90	17.32	38.92	24.72	9.73	13.44	26.87	15.62	14.01	11.31	12.06	9.83	9.13	7.37
+ delineation	47.74	29.32	18.90	11.67	33.31	19.66	6.93	9.08	22.26	11.81	9.72	7.40	9.83	7.30	6.14	4.66
+ paved shoulder	39.96	24.41	15.50	9.38	28.82	16.76	5.73	7.39	19.99	10.44	8.71	6.50	8.61	6.29	5.91	4.47
+ rumble strips	34.76	21.13	13.22	7.85	25.81	14.83	5.17	6.46	18.94	9.93	7.94	5.73	8.37	5.92	5.23	3.79
+ sight distance	34.45	20.95	13.13	7.81	23.49	13.63	4.88	6.17	17.15	9.18	7.50	5.50	7.62	5.48	5.00	3.69
+ roadside clearzone/barriers	29.25	17.67	11.05	6.61	20.48	11.70	4.46	5.52	16.70	8.66	6.98	5.13	7.37	5.10	4.61	3.46
+ median treatment	24.04	14.39	8.18	4.09	17.47	9.76	3.17	3.49	14.32	7.45	5.01	2.88	6.36	4.26	2.75	1.30
+ intersection lighting	23.95	14.33	8.15	4.08	16.75	9.39	3.08	3.40	13.77	7.21	4.87	2.81	6.12	4.12	2.68	1.27
+ int. protected turn lanes	Not applicable				14.90	8.44	2.85	3.16	12.34	6.61	4.53	2.63	5.52	3.78	2.50	1.20
+ int. chanelization					14.65	8.31	2.82	3.13	12.21	6.56	4.50	2.61	5.47	3.75	2.49	1.19
+ motorcycle lanes	11.05	6.93	4.35	2.48	8.73	5.42	2.11	2.43	10.05	5.65	3.97	2.34	4.86	3.40	2.31	1.12
+ traffic calming	10.92	6.86	4.31	2.46	8.19	5.14	2.05	2.36	9.62	5.46	3.86	2.29	4.68	3.29	2.25	1.09
+ roundabout (instead of regular int. and traffic calming)	Not applicable				15.27	8.63	2.89	3.21	12.63	6.73	4.60	2.66	5.64	3.85	2.54	1.21

Keys:

5-star
4-star
3-star
2-star
1-star
Not applicable

Table 13: Pedestrian Star Ratings

Highway classification	Primary				Class I				Class II				Class III			
Terrain classification	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**
Baseline	104.0	94.3	92.2	53.2	85.3	82.3	24.4	30.4	73.7	40.9	26.2	13.0	26.1	17.8	9.2	2.8
+ paved shoulder	87.3	76.8	71.7	39.5	73.6	67.6	19.0	22.8	63.8	33.3	20.5	9.9	22.4	14.4	7.2	2.1
+ rumble strips	73.9	64.8	60.1	32.8	64.3	58.4	17.2	20.1	61.8	31.0	18.5	8.8	21.7	13.4	6.5	1.8
+ sight distance	52.0	45.6	42.3	23.1	45.3	41.1	12.1	14.2	43.6	21.8	13.1	6.2	15.3	9.4	4.6	1.3
+ sidewalk	14.4	12.0	9.6	4.1	19.8	16.1	3.7	3.8	21.0	9.1	4.8	2.1	7.0	3.7	1.6	0.4
+ pedestrian crossing	4.1	3.4	2.7	1.2	6.9	5.7	1.4	1.4	14.1	6.2	3.3	1.4	4.9	2.6	1.1	0.3
+ lighting	4.0	3.3	2.7	1.1	6.4	5.3	1.3	1.4	12.3	5.4	2.9	1.2	4.4	2.3	1.0	0.2
+ fences	0.5	0.4	0.3	0.1	2.6	2.3	0.6	0.7	7.8	3.5	1.9	0.8	2.4	1.3	0.6	0.1
+ traffic calming	0.4	0.3	0.3	0.1	2.2	2.0	0.5	0.6	6.3	2.8	1.6	0.7	2.0	1.1	0.5	0.1

Keys:

5-star
4-star
3-star
2-star
1-star
Not applicable

Table 14: Bicyclist Star Ratings

Highway classification	Primary				Class I				Class II				Class III			
Terrain classification	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**	**L**	**R**	**M**	**S**
Baseline	344.3	324.3	230.7	127.2	250.4	181.6	53.3	70.2	137.0	78.7	54.8	29.2	45.6	35.4	20.1	5.9
+ delineation	269.4	240.8	160.3	83.3	198.1	132.3	36.0	45.5	105.0	55.0	36.4	18.8	35.1	24.9	13.4	3.8
+ paved shoulder	216.0	193.0	128.4	66.7	160.8	107.1	29.1	36.7	85.9	44.7	31.2	16.2	28.8	20.3	12.2	3.4
+ rumble strips	173.2	154.7	102.9	53.5	130.9	86.9	25.6	31.5	81.6	40.2	27.2	13.8	27.4	18.3	10.6	3.0
+ sight distance	122.0	109.0	72.5	37.7	92.2	61.2	18.1	22.2	57.5	28.4	19.2	9.8	19.3	12.9	7.5	2.1
+ bicycle facilities	2.0	1.7	1.1	0.6	7.2	46.3	13.7	16.8	43.7	21.5	13.7	7.0	19.3	12.9	7.1	2.0
+ lighting	1.6	1.3	0.9	0.5	5.8	37.0	10.9	13.4	34.9	17.2	11.0	5.6	15.4	10.3	5.7	1.6
+ traffic calming	1.4	1.1	0.7	0.4	4.7	33.0	9.5	11.3	31.6	14.9	9.3	4.7	13.9	9.0	4.8	1.4

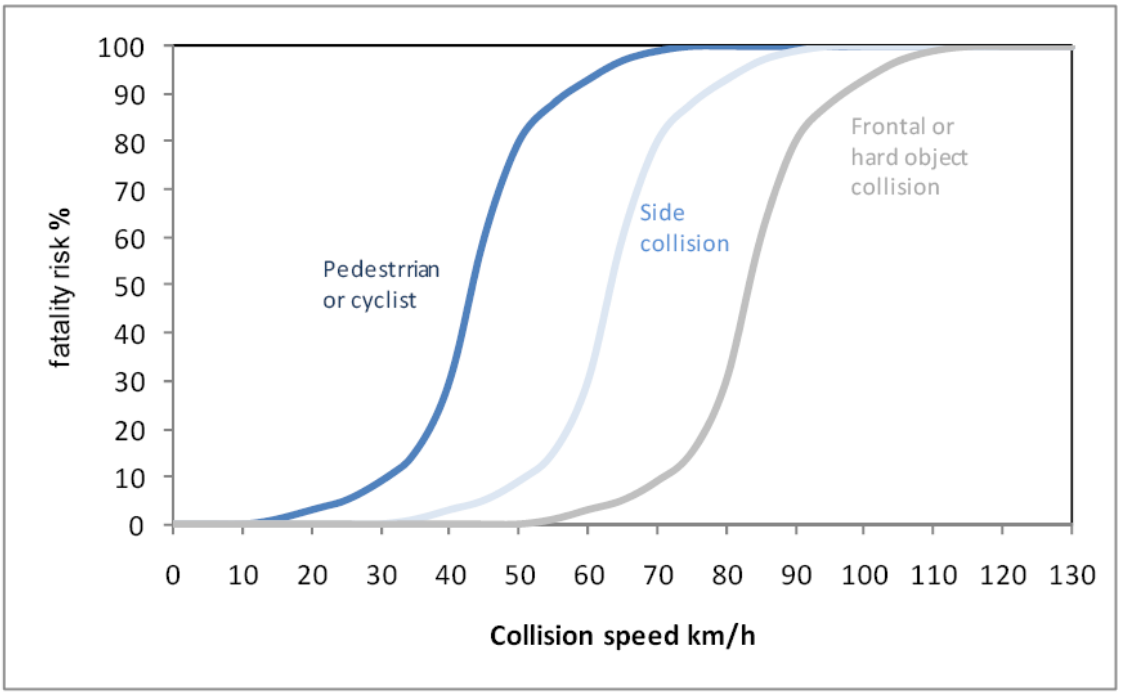
Keys:

5-star
4-star
3-star
2-star
1-star
Not applicable

Traffic Speeds and Star Ratings

Traffic speeds are a particularly important factor in road safety and in the Star Ratings. The relationship between speed and fatality risk is illustrated below in Figure 15, a feature of which is that risk rapidly increases between 40km/h and 50km/h for pedestrians, between 55km/h and 60km/h for side impacts and between 80km/h and 90km/h for head-on crashes.

Figure 15: The risk of a fatality increases rapidly as speed increases

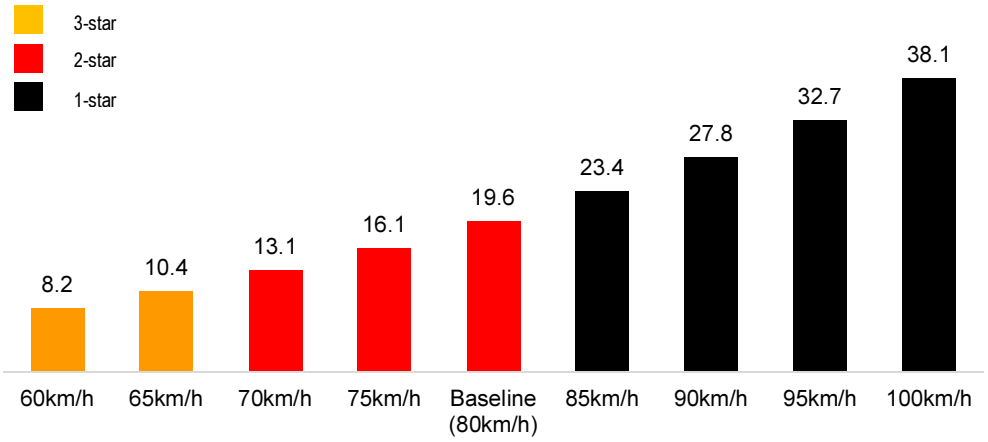


Source: OECD.

The Star Ratings in this study are based on the assumption that operating speeds are equal to design speeds set in the Asian Highway design standard. However, if operating speeds are even marginally higher than design speeds, the Star Ratings would decline and risk increase markedly. Conversely, lower speeds will lead to markedly lower levels of risk.

To further illustrate this point, the chart below in Figure 16plots Star Rating Scores and Star Ratings for the baseline Class I highway in Rolling terrain scenario. As was described in the earlier results section, if the operating speed is assumed to be the same as the design speed - 80km/h - then highway is rated 2-star. However, if operating speed is 85km/h or higher, the road is rated 1-star. If the operating speed is 65km/h or 60km/h, the rating is 3-stars.

Figure16: Speed sensitivity testing for the Class I highway in Rolling Terrain baseline scenario



8.7 Discussion and conclusion of the star rating testing

The iRAP methodology was used to illustrate how relative risk levels for vehicle occupants, motorcyclists, pedestrians and bicyclists would change if a range of Road Infrastructure Safety Facilities (RIF) were added to the standard.

The analysis shows that, with some exceptions, the Star Ratings for the existing AH Standard 'baseline' scenarios are in the high risk 1- and 2-star ranges. This reflects a combination of very limited infrastructure provision that is specified in the AH design standards and, especially in the Level and Rolling terrain classes, relatively high speeds.

Without exception, the addition of the RIFs results in reductions in risk. In terms of risk reductions, the following RIFs are among the most effective:

- Off-road bicycle paths.
- Fences to prevent pedestrians crossing.
- Sidewalks.
- Pedestrian crossings.
- Median treatments.
- Roadside clear zones / safety barriers.
- Roundabouts (compared with unsignalized 4-leg intersections).

At least a 3-star rating was achieved for each of the road user types. In the case of Class II and Class III highways, which have very low design speeds, either the baseline scenario achieves

at least 3-stars or 3-stars can be achieved with the application of one or a few RIFs, such as delineation. For the higher speed roads, significantly more RIFs are required in order to achieve a 3-star or better rating. This is especially the case for vulnerable road users.

The analysis also emphases the fact that, in terms of safety, higher speeds can be tolerated when there is sufficient infrastructure provision. Where infrastructure is insufficient, lower speeds are necessary in order to reduce risk. This also highlights the important role that speed enforcement can play in ensuring that operating speeds do not exceed the infrastructure provision. This can be achieved through numerous means, including police enforcement and fixed speed cameras.

Overall, this analysis indicates that achieving a minimum of a 3-star rating for all road users on the AH network is feasible through the application of a range of reasonable well-known RIFs that could be included in the AH Standard. In the future, the results of this study could be refined and expanded on by testing more scenarios (for example, with varying traffic flows, intersection types and RIF application frequency) in order to further inform policy and planning.

9. Considerations and Scope of the Design Standards

9.1 Considerations for the development of the design standards

In the development of the design standards for the selected road infrastructure safety facilities, the following assumptions were made:

- The design standard has to be universally applicable and practically achievable for the Asian Highway network across 32 member countries. Such standard should also be compatible with national standards in the member countries.
- It is necessary to take into consideration the vast difference in established practices and economic status among these countries. Traffic conditions may also vary substantially between and within countries in terms of traffic flows, vehicle composition, vehicle performance and road user behaviour.
- Where feasible and practical, the design standard should encourage harmonization of safety equipment and their usage. Admittedly, there are already substantial differences in technical standards among countries. In such circumstances, the design standard should aim at harmonization of the more universal principles.
- The objective of three-star rating is a minimum requirement and good performing countries should lead the way to achieve even higher star ratings. It would be desirable to review and update the design standard from time to time.

9.2 Scope of the design standards

The design standard is a comprehensive document which addresses road infrastructure safety facilities from both the road planning and design perspective. The design standard involves both active provision of RIFs and avoidance of undesirable practices or design.

Two very important safety approaches in contemporary era are “Self-explaining Roads” and “Forgiving Design”. The concept of self-explaining roads encourage road designs which promote road-users to adopt appropriate speeds and behaviour. This subject touches on consistency of alignment design and a well-defined road hierarchy, and should be introduced into the design standard wherever applicable. Forgiving designs aim at giving road-users adequate rooms for errors and limiting the severity of injuries in case of a crash.

Since almost 30% of the AH Network is Class III or below, the design standard contains guidance on the appropriate road safety treatments for these roads, bearing in mind that some of them are located

in very difficult terrains and could be single lane facilities. However, it is appreciated that the AH Network is gradually migrating towards primary, Class I and Class II roads. Accordingly, a major emphasis is given to the road safety needs for these road categories.

The design standard needs to addresses road safety at the interface between different road types. This is particularly important since the AH Network is ever undergoing development in response to traffic growth. A major concern arises where a primary road terminates at an at-grade intersection or onto a road with low standard alignment.

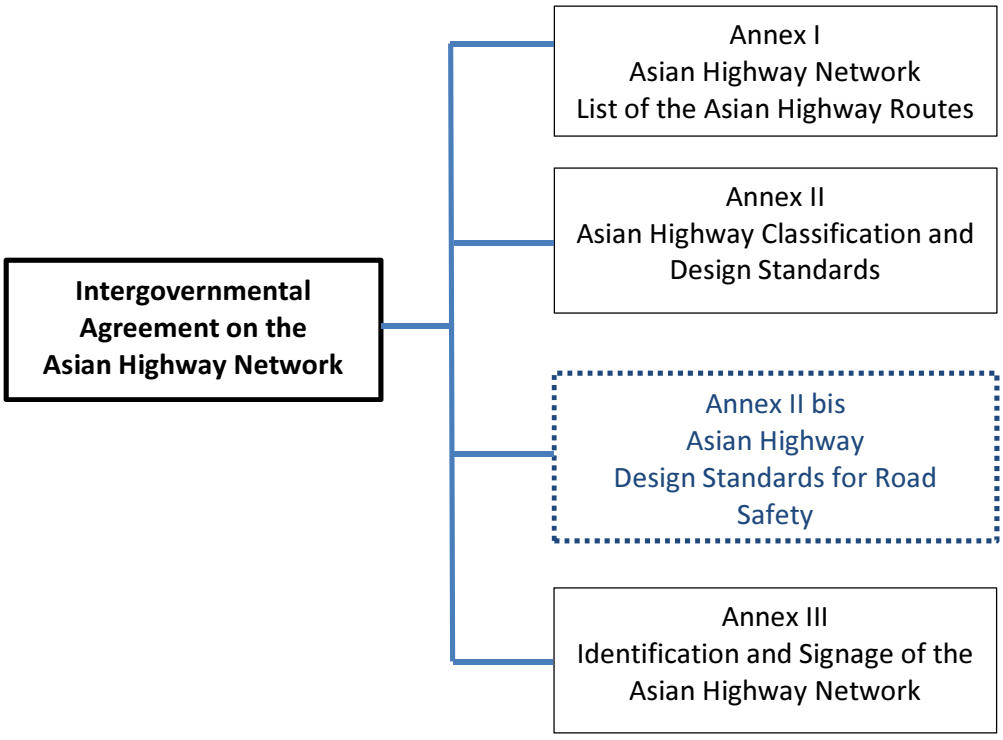
9.3 Structure of the design standards

The design standard as developed in this study and presented at the end of this report consists of two components:

1. Design Standards: this contains mandatory requirements. It is proposed that these would form Annex II bis of the International Agreement on the Asian Highway Network as shown in Figure 17.

2. A Detailed "Design Guideline": this consists of recommendations pertaining to the design standards.

Figure 17: Proposed Updated Structure of the International Agreement on the AH Network



Under this approach, the design standard addresses road safety from a holistic perspective incorporating modern concepts such as self-explaining roads and forgiving design. To reflect the importance of the selected RIFs, however, these will be given additional weights.

The advantage of this approach is that authorities, project offices and road designers tend to prefer solid requirements in the first place followed by supporting guidance. Other than certain mandatory requirements, the design standard seeks to inspire and motivate stakeholders to formulate solutions in their own contexts to satisfy the ultimate objectives i.e. three star ratings and enhanced safety performance of roads under the Asian Highway Network.

9.4 Evaluation of the Selected Road Infrastructure Safety facilities

This section summarizes findings on each selected RIF from literature review of existing design standard and practices from a variety of sources, notably information provided by the selected AH member countries and references from other AH member countries and comparison countries.

Unless otherwise stated, the quoted Crash Modification Factors (CMF) were obtained from the CMF Clearinghouse web site (www.cmfclearinghouse.org). CMF is not available for all the selected RIFs.

A-1 Line Marking

Line markings are a form of road signs laid on the road pavement to convey information which cannot be readily served by vertical traffic signs. One of their primary functions is delineation assisting drivers to keep to their lateral position. Some road markings indicate to drivers that they must not enter or cross. Line markings may be thermoplastic, cold plastic, preformed materials or paints laid on the pavement. Nevertheless, their performance could be undermined by rain, snow, dust and lack of maintenance. Edge line in conjunction with centreline has a CMF between 0.76 and 0.87.

The following line markings are considered basic provisions for delineation:

- Edge line
- Lane line
- Centrelines
- Deceleration or acceleration lane lines
- Chevron markings at grade-separated intersections

These markings are generally covered in national standards and used in all AH member countries. Certain AH roads do not have markings at all or markings are poorly maintained.

For centrelines, some countries adopt white colour whereas the others adopt yellow colour. Solid cum dotted line is not always used and single solid lines are commonly used instead of double solid lines. Harmonization in the use of line marking types is desirable but their colours could be maintained.

A-2 Chevron Mark

Chevron marks are vertical traffic signs with a pointed chevron symbol guiding drivers to negotiate a bend. They are generally provided along the outside edges of a bend alerting approach drivers of the existence and severity of the bend. Installation of chevron marks in conjunction with bend warning signs generally has good effects with a CMF between 0.49 and 0.76. One study found that additional sequential flashing beacons result in the most pronounced and consistent effect with a CMF as low as 0.23.

All the selected AH member countries use chevron marks. In China, green and blue background colours are adopted for expressways and other roads respectively. They are commonly used for the delineation of curves, sharp curves and interchange ramps. At least three marks should be visible at any time.

In both Republic of Korea and Thailand, chevron marks have a black and yellow colour scheme. At least two marks should be visible at any time. Their design standards also specify the distance between marks according to approach speed and curvature of the bend.

In the UK, the need for chevron marks is judged on an individual basis but consistency of usage is emphasized. The UK also suggests consideration for frangible supports to safeguard vehicle occupants and motorcyclists. In France, it is recommended to provide four levels of delineation according to the difference between approach speed and speed within the bend. A larger difference in speed requires more signs with chevron marks along the entire bend. A moderate difference in speed requires a single double chevron mark.

Chevron marks are also commonly used at roundabouts, end of a highway at a T-intersection and sometimes at pinch points for traffic calming.

A-3 Raised pavement marker

A raised pavement marker, also known as cat's eyes or road studs, is a safety device installed on the pavement in conjunction with line markings. These markers generally contain a lens or retroreflective materials to assist drivers visualizing the road layout at night time. They are particularly useful in rain, fog or darkness when line markings become less visible. Raised pavement markers have a CMF between 0.69 and 0.81. A lower CMF is achieved when used in conjunction with line markings.

In China, the colour, position and spacing of raised pavement markers are defined in national standards. They are unidirectional and have identical colour with the associated pavement markings. Raised pavement markers on centrelines or in tunnels are bidirectional. They are deployed for the following road types outside edge lines:

- primary roads
- interchanges, service areas and laybys of Class I highway
- diverging or merging areas at interchanges
- tunnels

In the Republic of Korea, raised pavement markers are used on all types of roads to supplement line marking for traffic during night time and adverse weather. Another function is to generate noise to warn drivers crossing line markings. They are installed where necessary in conjunction with line markings and where guidance through curves and a change in road environment is required. Standard spacing of raised pavement markers may be adjusted according to engineering judgement.

In India, raised pavement markers are required on all types of highways with elaborate criteria for their use.

In Thailand, raised pavement marker is defined in the national standard. The Department of Highways has recently started using a 360-degree raised pavement marker.

A-4 Flexible Delineation Posts

Delineation posts are slender posts with reflective elements on the roadside to provide guidance of the road alignment or to demarcate intersections, roadside hazards or a change in cross-section. They have a CMF of 0.55 if used in conjunction with edge lines and centerlines. They should be passively safe, being frangible and preferably self-restoring after an impact.

In China, delineation posts are extensively used on all types of roads. The national standard specifies their use on the mainline and interchange of primary roads and Class 1 roads. Delineation posts are also widely adopted on Classes 2 and 3 roads. The maximum spacing between posts is 50m on straight sections and has to be reduced at curves. They may be substituted by reflectors or light-emitting units mounted on safety barriers or kerbs. Other forms of delineation posts in use in China are marker posts at intersections or accesses. Similar reflective posts are used to delineate roadside hazards such as high slopes and rigid objects.

In India, flexible delineation posts are not yet covered in manuals or codes.

In Thailand, delineation posts are installed with spacing at 6 to 90m in the following locations:

- Horizontal and vertical curves.
- Locations with change in roadway width or alignment.
- Locations with extra delineation.
- Locations with confusing roadways.

In France and the UK, delineation posts are not standard equipment by default. They are deployed mainly at bends, intersections and where needed by road conditions. In the UK, marker posts with chainage are installed on the roadside of motorways at 100m intervals for emergency and maintenance positioning purpose. They display the chainage, direction to the nearest emergency telephone and indication if central reserve openings are in the proximity.

B-1 Roadside Barrier

Roadside safety barriers are longitudinal facilities to prevent an errant vehicle colliding onto aggressive features or other road-users on the roadside. Aggressive features include those stopping the vehicle abruptly, penetrating the vehicle compartment or causing the vehicle to roll or fall over. They are also designed to limit the injury for vehicle occupants and to redirect vehicle with a safer trajectory. Roadside safety barriers may be flexible, semi-flexible or rigid. Common types of roadside safety barriers are W-beam barriers, Thrie-beam barriers, New Jersey barriers, F-barriers, Dutch step barriers and parapets. In some countries, roadside barriers are specified by performance rather than prescriptive design. In China, roadside barriers are classified into five grades according to their anti-crash performance in terms of acceleration and crash energy.

Anti-crash level	Crash conditions			Crash acceleration (m/s^2)	Crash energy (kJ)
	Speed (km/h)	Mass of vehicle (t)	Crash angle (degree)		
B	100	1.5	20	≤ 200	
	40	10	20		70
A, Am	100	1.5	20	≤ 200	
	60	10	20		160
SB, SBm	100	1.5	20	≤ 200	
	80	10	20		280
SA, SAm	100	1.5	20	≤ 200	
	80	14	20		400
SS	100	1.5	20	≤ 200	
	80	18	20		520

In practice, roadside barriers are extensively used on all classes of roads in China. Common barrier types are W-beam, Thrie-beam, F barriers and bridge parapets. Their use on Classes II and III roads is more restricted to high risk sections, notable high slopes and cliff edges.

In the Republic of Korea, roadside safety barriers are extensively used on all types of roads. Common barrier types are W-beam, Thrie-beam, New Jersey concrete barriers and bridge parapets. Taller double layer safety barriers are used over high slopes.

In India, roadside safety barrier is covered in the design standard for the various road types.

In Thailand, the main barrier types are W-beam guardrails and New Jersey concrete barriers. It is up to the designers, situations and circumstances to choose either barrier types as roadside or median barriers. They are mainly deployed in the following conditions.

- There are possible hazards from roadside.
- Height of embankment of roadway is larger than 5m (7m maximum) and side slope is steeper than 1:3.
- Downhill gradient > 6% and height of embankment > 3m.
- Water at the toe of slope is deeper than 1.50 m.
- Radius of a horizontal curve is smaller than 150 m.
- There are hazardous topographies, such as rivers, deep valleys, or rocks, on the fill slope which may cause serious damage to vehicles.

The Roadside Design Guide of the United States contains comprehensive guidance on the use of roadside safety barriers. Norwegian design manual 231E provides useful guidance on the usage of safety barriers. In the UK, design standard TD19/06 illustrates the key consideration for safety barriers to EU requirements. Important concepts include working width, length of need etc.

In Hong Kong, specially designed and tested Thrie-beam and parapets are available for the containment of 22t double-decker buses at 50km/h. Their use is subject to a risk scoring assessment.

B-2 Median Barrier

Median barriers are safety barriers to prevent an errant vehicle colliding onto aggressive features on the median or opposing traffic. Barrier type and design are the same as roadside safety barriers, except that double sided barriers are often used on narrower medians.

In Bangladesh, New Jersey safety barriers are generally used for medians.

In China, median safety barriers are provided according to the following principles:

- if the width of the median of is less than or equal to 12m, median safety barriers must be deployed
- if the width of the median is larger than 12m, the deployment of median barriers depends on prevailing conditions
- if the two directions of a highway is constructed on separate road formations, safety barriers shall be deployed on the left side; if the level difference is larger than 2m, safety barrier should be deployed on the higher elevation road base.
- movable barrier must be deployed for motorway and median openings of Class I highway with prohibited U-turns
- road sections with high probability of serious outcome due to road alignment, operating speed, traffic volume and traffic composition shall have barriers with higher containment levels

In India, median safety barrier is covered in the design standard for the various road types.

In Thailand, both W-beam and New Jersey safety barriers may be used for medians.

B-4 Central Hatching (Painted Median)

No information has been received about the use of central hatching from the selected AH member countries. Central hatching is not found in samples of AH roads in Bangladesh and Thailand using Google Street View. It is not used on single carriageway roads in China.

In other AH member countries, wide centreline marking does not appear to be commonly used on single carriageway roads. A wide centreline is used on single 4-lane or single 6-lane Class I roads on AH84 in Turkey.

Wide centreline treatment has a CMF of 0.4 for all crashes. It helps to increase separation between opposing traffic but is less effective in reducing speeds. The preferred width is 1m and is more effective when used in conjunction with raised profile line marking or rumble strips.

In the Netherlands, wide centreline is extensively used for 80km/h and 100km/h single carriageway highways. A dotted version is also used to permit overtaking with caution. Similar applications have gain popularity in Australia.

In France and the UK, wide centreline treatment is extensively used to discourage overtaking at bends, crest and sometimes on straight sections.

B-5 Crash Cushion with Channelization

There is a very high risk of vehicles colliding onto diverge gores at interchange due to loss of control or abrupt manoeuvres. Severe casualties can result if the errant vehicle collides with aggressive roadside features at the diverge gore. Crash cushions are installed to redirect or bring the errant vehicle to a controlled stop, thereby reducing the potential of serious injuries. Crash cushion is highly effective for this purpose as demonstrated by a CMF of 0.31.

In China, design standard of crash cushions has been developed recently. There are three categories for 60, 80 and 100km/h. In the Republic of Korea, there is a comprehensive standard of crash cushions and they are extensively deployed on primary roads and Class I roads in the AH Network. In India, requirements for crash cushions to NCHRP Report 350 (US) are given in the design standard for highways. No information has been received about the use of crash cushion in Bangladesh and Thailand. Crash cushions are not found on AH roads in Bangladesh and Thailand using Google Street View.

Crash cushions were developed in the United States in the 1970s and are extensively used in Europe, Australia, Japan and Hong Kong. In Hong Kong, crash cushions are required at diverge gores on high speed roads with speed limit of 70km/h or above. Their use is partly due to space constraints where clear zones are often not practical.

B-6 Safety Barrier End Treatment

There is a very high risk of vehicles colliding with the end terminals of safety barriers due to loss of control. Severe casualties can result if the errant vehicle is stopped abruptly upon impact. Metal safety barriers may also penetrate into the vehicle compartment. Some end terminals have sloping end which can launch an errant vehicle at high speed air-borne. Appropriate end treatments of safety barriers reduce the risk of injuries due to the above collision mechanisms.

In China, curly safety barrier end terminals are generally adopted for both upstream and downstream ends. Flaring is not specified but sometimes adopted on a project basis. The standard consists of a transition design between W-beam safety barriers and concrete safety barriers.

In India, end treatments are covered in the design standard for the various road types.

In Thailand, there are two types of treatment for W-beam barriers, namely concrete anchor end treatment and turned-down fish tail end treatment. For concrete barriers (New Jersey type), the end terminal is progressively ramped down. All terminals have flaring designs.

In the UK, "P4" terminals are required for all upstream safety barrier end terminals on roads with speed limit of 80km/h or above. These are end treatments tested at 100 to 110 km/h.

B-7 Clear Zones

Causes for vehicles crashing onto highway roadsides are diverse and cannot be readily eliminated. Severe casualties can occur if an errant vehicle collides with aggressive fixed objects. In other cases, the vehicle may roll over a steep side slope or else fall over a sheer drop. A clear zone comprising side slopes of very gentle gradient and free of aggressive features will help to reduce the severity of casualties. Clear zones have a CMF between 0.58 and 0.82.

In China, the design standard does not specify the requirements for clear zones. However, the guide on the "Cherish the Life Project" contains specific guidance on clear zones and safety barriers. Furthermore, the subject has attracted a lot of attention and interest in the highway community. In practice, however, clear zones are not frequently designed and constructed in the highway system.

In India, a clear zone of 11.0m is specified. The clear zone consists of paved shoulders, a traversable side slope at an 1:3 gradient. An additional run out area is also specified.

No information has been received on clear zone standards in Bangladesh, Republic of Korea, and Thailand.

In France, the width of clear zone on expressways is specified as 8.5m (110km/h) and 10m (130km/h) respectively.

The design standard of Norway is based on both traffic volume and speeds. The Norwegian standard also contains the criteria for a clear zone in a variety of typical roadside conditions. This serves as a good reference in conjunction with other requirements from AASHTO and the UK.

C-2 Centreline/Edge line Rumble Strip

Rumble strips are indentations on the pavement generating vibration and sound when driven over. The main purpose is to alert drivers drifting away from their traffic lanes due to inattention or fatigue driving. They are also used to discourage drivers crossing onto hatched areas or overtaking on opposing lanes. Edge and centreline rumble strips have a CMF between 0.51 and 0.92.

In China, rumble strips are frequently used on the outside of edge line on primary roads. They are not regularly used on other roads. Installation on centreline of single carriageway is uncommon.

In the Republic of Korea, rumble strips are used on highways outside cities. They are not used around an interchange, in a tunnel or over bridge structures. They are retrofitted onto existing roads where warranted by frequent crashes due to inattention or fatigue driving. The preferred technique for installation is milling for asphalt pavement and rolling for concrete pavement.

In India, raised rib edge line markings are covered in the design standard. However, their use is discouraged on curves for the safety of two wheelers. No information has been received on standards and practices in Bangladesh and Thailand.

In Scandinavian countries, rumble strips are extensively used on primary roads and other rural roads. These include rumble strips milled into the pavement or raised rib markings.
In the UK, raised rib markings are extensively used for hard shoulder and edge lines. They are also used as edge lines forming chevron markings and hatched markings at lane reduction. Besides the audible-vibratory warning they offer, these markings help to improve retroreflective performance of a wet pavement. There are strict requirements for the maximum height and location of installation pertaining to possible hazards for pedestrians, cyclists and motorcyclists.

Centreline rumble strips have been successfully deployed in Hokkaido, Japan (CERI). It is reported that 9mm and 12mm milled rumble strips are used over the centreline and roadside shoulder respectively. They are also used on curves and are effective in uncompacted snow.

D-1 Pedestrian Crossings

In China, pedestrian crossings are provided for all signalized crossings in urban areas. They are also provided as marked but uncontrolled crossings in towns and villages on Classes I, II and III highways.

In India, criteria are set for pedestrian crossings on two-lane highways. For four or six lane highways, pedestrian crossings have to be grade-separated or else controlled facilities around intersections.

In Bangladesh and Thailand, there exist standards of pedestrian crossings. In general, non-signalized crossings have to be preceded by warning signs and 50km/h speed limit signs. Along the AH network, however, marked crossings are infrequent. There are occasional footbridges along major Class I roads in Thailand.

D-2 Sidewalk (Footpath)

In Bangladesh, footpaths are not generally provided along highways but are provided in some recent projects e.g. along the bridge crossing on AH2 at Bhairab Bazar.

In China, footpaths are generally provided within larger towns and cities including those traversed by highways, but they are not usually provided in smaller towns and villages as this is not specified in the highway design standard. Local governments and communities may opt to construct footpaths.

In the Republic of Korea, footpaths are generally provided within urban areas. Information has not been received about their provision on highways. It is noted that the AH Network in the Republic of Korea is mainly expressway.

In India, the requirement for footpaths of 1.5m minimum width is covered in the design standard for highways. Additionally, increased protection including 200mm high kerbs and safety barriers or pedestrian fences is specified for four-lane or six-lane roads.

In Thailand there is no design standard for footpath on highway although 2.4 – 2.5m is generally used.

D-3 Pedestrian Fences

Pedestrian fences are physical barriers used for the control and guidance of pedestrians along sidewalks.

In China，pedestrian fences are generally provided in towns and cities traversed by highways, but they are not usually provided in smaller towns and villages. In Bangladesh and Thailand, pedestrian fences are rarely used on the AH network.

In India, requirements are given for the use of pedestrian fences on two lane highways.

Use of pedestrian fences varies among countries. In the Netherlands, pedestrian fences are not used. In the UK, pedestrian fences are regularly used. In the last decade, however, there is a tendency to substantially reduce the amount of pedestrian fences. Blocking of visibility also considered a potential problem with pedestrian fences at crossings.

D-4 Pedestrian Refuge Island

Pedestrian Refuge Island is an area in the middle of a road designated exclusively for pedestrians and sometimes slow vehicles. It is generally bounded by kerbs and possibly safety barriers to prevent intrusion by vehicles. They may be standalone facilities on a single carriageway road. On dual carriageway roads, they are part of the median.

In China, pedestrian refuge island is specified if the carriageway width is larger than 30m. In practice they are only adopted on dual carriageway urban roads. They are rarely adopted on single carriageway highways. In Thailand, pedestrian refuge island is not used.

In India, there is no guidance on pedestrian refuge at locations other than pedestrian crossings forming part of a channelized intersection.

In other countries studied, pedestrian refuge island is an option for urbanized sections of highways and at intersections with protected turn lanes. They are considered beneficial at higher traffic volume to facilitate pedestrians crossing in two steps. The alternative is to provide build-outs, being local inward extension of the footpath. In France, refuge islands should be 2.1m wide to accommodate wheelchair users. In the UK, a minimum width of 1.5m is specified. Additionally, as refuge islands constitute a pinch point, carriageway width between 3.1m and 3.9m is discouraged if there is frequent bicycle traffic.

E-1 Protected Turn Lane

Protected left turn lanes provide a refuge for turning vehicles to slow down, wait and queue, thereby causing reducing the disruption to through traffic. This in turn reduces the risk of rear-front collisions. Protected turn lanes can be integrated with pedestrian crossing facilities and may be readily upgraded to signalized intersections. Protected left turn lane has a CMF of 0.73 for 3-leg intersections but 0.96 for 4-leg intersections.

In China, protected left turn lane is specified for 4-lane highways unless left-turn traffic is very low. Protected left turn lane is specified for high standard single 2-lane highways if the intersection leads to an expressway or similar highways, there is a high volume of non-motorized vehicles and where left-turning leads to congestion or collisions. In practice they are not frequently adopted outside cities other than at signalized intersections.

In India, protected turn lane intersections with hatched markings or traffic islands are covered in the design standard for highways.

In Thailand, it is specified on the basis of turning traffic volume but there is no further information about their layout and frequency of usage. From Google Street View, protected turn lane is not used on single carriageway roads of AH1 and AH2, U-turn/left turn lane is systematically adopted on dual carriageway roads of AH1 and AH2.

E-2 Intersection Channelization (Side Road Deflection Islands)

This measure is beneficial in that main road turning traffic is forced to follow a designated path at reduced speeds. Drivers approaching from the side road will be better alerted and compelled to slow down by the island geometry. This is particularly important at crossroads. The deflection island may also be designed to serve as a central refuge allowing pedestrians to cross in two steps. CMF of 0.2 and 0.5 are quoted in the design manuals of the UK and France respectively for rural crossroad intersections.

In Bangladesh, deflection islands are not included in the standard. From Google Street View, they are sometimes used in association with major highway improvement schemes.

In China, deflection islands are rarely adopted at highway intersections but may be used at highway signalized intersection. In Thailand, they are not or rarely used at highway priority intersections, but are generally used at highway signalized intersections.

In India, deflection islands on hatched markings are illustrated in the design standard for highways. It is not clear whether physical traffic islands are used.

E-3 Roundabouts

Roundabouts are intersections whereby traffic circulates around a central island in one direction and traffic entering the roundabout must give way to circulatory traffic. All traffic has to slow down on the approach and negotiate the roundabout at reduced speeds. The primary safety benefit of roundabout is minimum conflict points and any potential conflicts take place at a safer angle at lower speed. Roundabouts have a very good safety record but this also depends on design parameters and traffic conditions. It is therefore very important to set down essential safety principles in the Design standard.

No information has been received from the selected member countries on roundabout design standard. An exception is India where some basic parameters are available for roundabouts on four lane roads. From Google Street View, roundabouts are not common but occasionally used in these countries. In Bangladesh, for example, roundabouts are sometimes used in the AH Network, both in urbanized areas and in conjunction with major bridges.

In some European countries, notably Scandinavia, France and the Netherlands, single lane "Continental" roundabouts are very popular at highway intersections. In the UK, there are more variations in roundabout design and capacity is often maximized by adding traffic lanes at entries. Turbo roundabout is a potentially safer and more efficient form of two lane roundabouts.

F-1 Speed Humps

Speed humps are physical traffic calming facilities which deter excessive speeds through vertical deflection.

In Bangladesh, speed humps have been successfully adopted in a demonstration project on AH2 in Bangladesh. The project achieved a CMF of 0.13 and 0.31 for fatalities and injuries over a period of 17 months.

In China, speed humps are sometimes adopted on Class 2 or 3 roads within towns and villages. These may be in the form of speed tables or rubber/steel speed humps. They are often installed on side roads immediately ahead of the intersection with a main road.

In India, there is national policy not to install speed humps on national highways including built-up areas. However, "speed breakers" equivalent to speed humps are used on minor roads with elaborate criteria in the design standard.

No information has been received from Korea and Thailand. Speed humps are not used according to Google Street View on the AH network.

In France, flat top speed tables with 1:7 approach ramps or speed cushions are recommended in urban areas. In the UK, a variety of speed humps are in use. Acceptability to bus operators is a major consideration.

In the Netherlands, speed humps are frequently used in urbanized areas, including sections on major roads. In general, these speed humps are relatively gentle and used in conjunction with traffic calming schemes.

F-2 Visual Traffic Calming

This topic is intended to address traffic calming in urbanized sections on the AH Network. This does not cover controlling traffic speeds on primary roads and other high speed roads relative to bends and other hazards.

In China, basic traffic calming is generally provided for urbanized sections of highways. Common measures include village name sign, speed limit signs, warning signs, rumble strips, school warning signs etc. A wider cross-section may be adopted through towns and villages to give extra space for slow vehicles but through road lane width is generally maintained.

In Bangladesh, visual traffic calming measures are very limited for urbanized sections of the AH Network. For crowded conditions, however, traffic calming is probably self-enforcing by virtue of the built-up environment and road conditions. Information has not been received from Korea and Thailand.

In India, there is no separate guideline on visual traffic calming. However, the use of gateway treatment is covered in the design standard.

In European countries including the UK, Netherlands and France, visual traffic calming is widely adopted with a wide range of possibilities. In addition to signs and markings, an important measure is to alter the cross-section of the road, through reduction of lane widths, provision of parking lanes and possibly deliberate removal of centreline and edge line markings. There is also an emphasis on the

contentious shaping of the road environment with plantings, street furniture, lighting etc to induce appropriate driving behaviour.

F-3 Automatic Regulation Cameras

There are several categories of automatic regulation cameras:

- Red light enforcement cameras (REC)
- Speed enforcement cameras (SEC)
- Combined red light and speed enforcement cameras
- Average speed cameras (ASC)

REC is installed just upstream of a traffic signal to detect vehicles passing a red light with visual record. SEC detects speeding vehicles at designated sites and provides a visual record of violation. More sites can be designated and cameras are installed on rotation. Combined red light and speed enforcement cameras are used to enforce either or both red light and speed violations. ASC use two or more cameras based on automatic number plate recognition technology to deter and enforce speeding on a route or route sections.

In China, both Red light and speed enforcement cameras are extensively deployed on highways. They are general overhead-mounted and highly visible. Their locations are generally well announced by in-vehicle GPS route guidance device.

The following table summarizes the CMF of enforcement cameras from some studies.

Type	Source of information	CMF
Red Light Enforcement Cameras	Hong Kong	0.45-0.56 (violations)
	International	0.80-0.90 (all) 0.76-0.83 (fatal) 1.18 (rear-front collisions)
Speed Enforcement Cameras	Hong Kong	0.50 (>15km/h above speed limit) 0.60 (collisions)
	International	0.70-0.98 (all) 0.83 (all casualties) 0.74 (rear-front collisions)
Combined Red Light and Speed Enforcement Cameras	International	0.72-1.05 (all) 0.86-0.88 (fatal, serious injury)

		1.33-1.70 rear-front collisions) - (Fixed) 0.31-0.95 accident - 0.35-0.88 injuries - 0.29-0.83 fatal - (mobile, hidden) 0.65-0.85

No information on automatic regulation camera has been received from other AH selected member countries.

In France, it was inferred that large scale deployment of speed enforcement cameras contributed to a significant decrease of road fatalities. It was estimated that over the 7-year period between November 2003 and December 2010, speed enforcement cameras prevented 15,193 fatalities and 62,259 casualties in France. This equates to a CMF of 0.79. However, it was also recognized that the effectiveness tends dilute over time.

In the UK, average speed camera systems now cover 420km of roads and are expanding. In Australia, these are known as Red-light Speed Cameras (RLSC) and their use is ever expanding.

It is recommended that this topic is covered under deployment of Intelligent Transportation Systems (ITS).

G-1 Bicycle Lane

Bicycle lanes are facilities to separate bicycles from vehicle traffic. On-road bicycle lanes are strips of the road pavement marked for bicycle travel. Off-road bicycle lanes are dedicated tracks for bicycle travel and are physically separated from the road pavement. At very low traffic speeds and volume, it may be adequate for bicycles and vehicles to share the road pavement. An important subject common to both facilities is bicycle crossings where a bicycle facility intersects the path of vehicle travel.

No specific information has been received from Bangladesh, Korea and Thailand. It is however known that bicycle lanes are generally provided in larger towns or cities in China. In India, a design guideline is available for cycle tracks on urban roads. In most countries, bicycles may use the shoulder of highways other than primary roads.

The Netherlands has extensive bicycle lanes and a large population of cyclists. The Netherlands also has an elaborate design standard for these facilities, both inside and outside built-up areas. The selection of segregated (off-road) or on-road bicycle lanes is based on road types, traffic speeds and the relative volume of vehicle and bicycle traffic.

Many other countries e.g. the UK, Ireland, Australia, the United States have developed their own design standard for bicycle lanes.

G-2 Exclusive Motorcycle Lanes

This facility is mainly adopted in Malaysia where traffic on major highways consists of a large volume of motorcycles. Motorcycle lanes may be provided as a segregated carriageway separated from the main flow with a safety barrier, as in the case of a primary road. Motorcycle lanes may also exist as a wide shoulder along single or dual carriageway roads. A widened shoulder line is beneficial to provide additional separation between traffic streams.

H-2 Lighting

The main safety function of road lighting is to light up the road pavement, road-users, vehicles and critical features for night time travel. Road lighting also helps to foster the personal safety of pedestrians and other road-users. The provision of road lighting in built-up areas is also symbolic to increase the awareness of drivers to slow down. Lighting has CMF of 0.31 for at-grade intersections and 0.5 for grade separated interchanges

In China, highway lighting is classified into asphalt pavement lighting and concrete pavement lighting. The specification sets out criteria including average road surface luminance, uniformity of road surface luminance, uniformity of road surface illuminance, glare limited, surround ratio and visually guided. Highway level of lighting can be classified into two levels due to application conditions. There are two levels of applications:

Level 1: High traffic density or/and bad sight distance or/and complicate road conditions
Level 2: Moderate traffic density, well sight distance, good road conditions

In India, the requirement for lighting is covered in the design standard for concessionaires of highway projects. The need for lighting provision on different road sections or facility is specified for each type of highways.

In Thailand, road lighting is generally provided in built-up areas and their vicinity along the AH Network. The Department of Highways has been using its own street lighting specifications since 1979. Lighting is generally based on 9 and 12-meter high poles or high mast poles for wide roads. Despite specification of illumination for different road types, 21.5 lux is generally used for design regardless of road types and locations. The specifications have been used since 1979 and are currently under review.

In France, isolated provision of road lighting is considered inappropriate for rural road intersections.

In the UK, the Design Manual for Roads and Bridges contains the requirement of road lighting for the strategic road network. There are elaborate requirements for treatments at lit and unlit sections of the highway. Road lighting is provided at built-up areas and the roads with heavy traffic.

In the US, the need for lighting highways, freeways, interchanges and bridges are undertaken using the AASHTO Roadway Lighting Design Guide Warranting System. AASHTO defines warrants for Continuous Freeway Lighting (CFL), Complete Interchange Lighting (CIL) and Partial Interchange Lighting (PIL) based on warrant conditions including:

- Traffic volumes
- Spacing of interchanges
- Lighting in adjacent areas
- Night-to-day crash ratio

Nevertheless, warrants only indicate the need for lighting should be investigated with sound engineering judgment. Some US authorities prefer a simplified approach based on road classes and traffic volumes.

AASHTO believes it is desirable to provide lighting on long bridges in urban and suburban areas even if the approaches are not lighted. On bridges without full shoulders, lighting can enhance both safety and utility of the bridges, and is therefore recommended. Where bridges are provided with sidewalks for pedestrian movements, lighting is recommended for pedestrian safety and guidance.

For intersections, the Transportation Association of Canada's Guide for the Design of Roadway Lighting is recommended. This guide contains a scoring system based on 19 criteria, the most important of which are bend radius, intersection frequencies, pedestrian activities and night-to-day collision ratio.

H-7 Stopping Sight Distance

Stopping Sight Distance (SSD) is the distance for a driver to bring a moving vehicle to a complete stop. SSD consists of two components, namely distance for perception- reaction and distance for braking. SSD in different countries varies due to assumed perception-reaction time and deceleration value at braking. Braking efficiency also differs between light vehicles and heavy vehicles.

The basic formula for SSD is $SSD = 0.278*v*t + v^2/(0.254\,(a/9.81 + g))$ where

v = speed (km/h)

t = driver perception-reaction time (seconds)

a = deceleration rate (m/s^2)

g = gradient value e.g. 0.05 for 5% gradient, downhill gradient in negative value

SSD is applied to a variety of situations to ensure that drivers can react to road features, pavement conditions and manoeuvres of other vehicles or road-users. The following table summarizes the requirements in the various countries.

SSD Values

Countries	Design Speed km/h						
	120	100	80	60	40	30	20
China	210	160	110	75	40	30	20
China (Trucks)	245 [273]	180 [200]	125 [139]	85 [95]	50	35	20
Thailand	-	185	130	85	50	35	20
Bangladesh	-	180	120	-	-	-	-
India	-	180	120	80	45	30	20
Korea	215	155	110	75	40	30	20
France	235	160 [187]	105 [121]	65 [72]	35 [40]	25 [26.5]	15 [15.5]
UK	295(215)	215(160)	150(110)				
UK MfS	-	-	-	56	31	20	12
TEM	200 {250}	150 {188}	100 {125}	-	-	-	-

[ ] Values to be adopted at maximum gradient permitted for the road class in China

( ) Values of “one step relaxation” not to be used at immediate approach to intersections but acceptable on free-flow sections in the UK

UK MfS: Manual for Streets, for street design =< 60km/h based on a=4.41m/s

{ } Sightlines are increased by 25% at curves with radius less than 5V, where V = speed in km/h

SSD in the United Kingdom is based on 2 seconds of perception-reaction time and 0.245 m/s^2 (0.25G) of deceleration rate. It is recognized that road surfaces normally can provide up to 0.45G in wet

conditions but 0.25 G is appropriate for snow-covered roads. In the UK, lower SSD values are now used for the design of urban streets with the thinking that smaller SSD foster lower urban speeds. This is based on 1.5 seconds of perception-reaction time and 0.441 m/s^2 (0.45G) of deceleration rate.

Visibility is based on the eye-height and position of an observer and targets to be observed. An observer would be a road-user and the target could be another road-user, a vehicle, vehicle lights, the road pavement, signs or safety facilities, objects etc. Definition of eye-heights, object types and object heights is an important component of setting requirements for SSD. The following table summarizes the requirements in the various countries.

Eye-heights, Object Types and Object Heights

	Drivers	Motor-cyclists	Cyclists	Pedestrians	Ground objects	Other vehicles
China	1.2- 2m	-	N	N	N	N
Thailand	-	-	-	-	-	-
Bangladesh	-	-	-	-	-	-
India	1.2m	-	-	-	0.15m	-
Korea	1.0m	-	-	-	0.15m	
France	1m	-	-	-	0.35m +	-
UK	1.05- 2.m	-	1- 2.2m	0.6-1.8*	0.26	1.05
TEM	-	-	-	-	-	-
Malaysia		1.43m	-	-	-	-

+ 0.15m on roads subject to falling stones

Availability of overtaking visibility is critical to the safety of AH Classes II and III roads. The following table summarizes the requirements in the various countries.

Overtaking Sight Distance

	Design Speed km/h						
	120	100	80	60	40	30	20
China	-	-	550 (350)	350 (250)	200 (150)	150 (100)	100 (70)
Thailand	-	-	-	-	-	-	-
Bangladesh	-	720	500	340	180	120	-
India	-	640	470	300-	165	-	-
Korea	-	-	540	400	280	200	150
France	-	500	500	500	-	-	-
UK	-	580	475	345	-	-	-
TEM	-	600 (400)	475 (325)	-	-	-	-

Decision Sight Distance (DSD) is based on pre-manoeuvre time which varies from 3s to 14.5s. DSD values are given in the following table from the AASHTO Green Book 2001. It is not recommended to

adopt DSD at this stage due to their large values which may not be practical for the purpose of the design standard.

Design Speed (km/h)	Decision Sight Distance for Avoidance Maneuver, (meters)				
	A	B	C	D	E
50	70	155	145	170	195
60	95	195	170	205	235
70	115	235	200	235	275
80	140	280	230	270	315
90	170	325	270	315	360
100	200	370	315	355	400
110	235	420	330	380	430
120	265	470	360	415	470
130	305	525	390	450	510

*Note: Avoidance Maneuvers
1. Avoidance maneuver A: Stop on rural road - t = 3.0[s]
1a. Stop on suburban road - Assume t = 6.0[s]
2. Avoidance maneuver B: Stop on urban road – t = 9.1[s]
3. Avoidance maneuver C: Speed/path/direction change on rural road – t=10.2 – 11.2[s]
4. Avoidance maneuver D: Speed/path/direction change on suburban road – t=12.1 – 12.9[s]
5. Avoidance maneuver E: Speed/path/direction change on urban road – t=14.0 – 14.5[s]
Source: AASHTO Greenbook, 2001.

9.5 Other road infrastructure safety facilities

A-5 Coloured Lanes

Coloured surfacing may include dressings, asphalt or paints with colours applied to the entire road pavement or a portion of it. They can enhance the visual appearance of the pavement and could be beneficial for the following purposes:

- traffic calming
- infilling of widened markings
- infilling of hatched markings at intersections
- paving shoulders and cycle tracks
- paving footpaths

Coloured surfacing lasts longer if paved over non-trafficked areas e.g. central hatching. Their use depends on availability of suitable materials and maintenance capacity. In the design standard, coloured surfacing is incorporated as options under various RIFs.

B-3 Slide to protect Headlight

In the absence of road lighting, high beam headlights from opposing vehicle is a potential safety problem, notably on expressways. The problem may also arise with parallel side roads. Screens or vegetation are commonly adopted over median barriers in China. In the UK, such screening is not considered to have a benefit and they are not standard equipment in many high income countries. There are a number of considerations in their provision, e.g. effect on forward visibility and maintenance safety for vegetation. The subject will be covered in the design standard.

C-1 Skid Resistance and Anti-skid Surfacing

Adequate skid resistance is crucial for road safety, especially on bends and where braking is required including approach to intersections. Skid resistance is particularly important when the road surface is wet.

For AH Primary Roads and Classes I, II roads with speed limit of 80km/h or above, open texture surfacing materials should be adopted to avoid aquaplaning at locations subject to heavy rains. Adequate skid resistance should be provided on the AH Network with priority given in the following order:

Priority 1

Approaches to intersections, roundabouts and traffic signals

Approaches to pedestrian crossings

Gradient >10% and longer than 50m (not for uphill gradient on one way roads)

Bend radius <500m for speed limit >= 80km/h on AH Primary and Class 1 Roads

Bend radius <100m for speed limit >= 50km/h on AH Primary and Class 1 Roads

Priority 2

Bend radius <500m for speed limit >= 80km/h on AH Classes 2 and 3 Roads

Bend radius <100m for speed limit >= 50km/h on AH Classes 2 and 3 Roads

Roundabouts

Gradient >5% and longer than 50m (not for uphill gradient on one way roads)

Priority 3

General section of AH Class 2, 3 Roads

General section of AH Class 1 Roads

AH Primary Roads

Anti-skid surfacing should be considered at Priority 1 sites. A maintenance program is necessary to ensure that the material is kept in good condition. Where there is notable skid resistance problem, possibly supported by crash data, skidding warning signs should be erected in conjunction with measures to reduce approach traffic speed.

F-4 Variable Speed Limit

This is generally covered under ITS but their relationship with fixed speed limit should be covered in the design standard.

G-3 Non-exclusive Motorcycle Lanes

In many countries, motorcyclists are already using hard shoulders of Class I, II or III highways. Shoulders for such purpose should be at least 2m wide. For high speed roads, an option is to incorporate a widened shoulder marking. This will be covered in the design standard under slow vehicle facilities.

G-4 Motorcycle-friendly Safety Facilities

The design standard should incorporate the use of motorcycle-friendly safety barrier design as an option for highways where leisure motorcyclists are present. Overall, a holistic forgiving roadside approach should be encouraged for the safety of all two wheel users.

H-1 Reflection Mirror

Reflection mirror would only be relevant for acute visibility problems on Class II or III roads at isolated locations. Such problems should be addressed by road treatments in the first place. They will not be recommended in the design standard.

H-3 Variable Message Sign

This is generally covered under ITS but their relationship with fixed directional signs should be covered in the design standard.

H-4 Roadside Parking

As an important guiding document for the Trans-European Road Network (TERN), directive 2008/96/EC of the European Parliament and of the Council states that "Sufficient roadside parking areas are very important for road safety. Parking areas enable drivers to take rest breaks in good time and continue their journey with full concentration. The provision of sufficient safe parking areas should therefore form an integral part of road infrastructure safety management." This topic should be incorporated in the design standard.

H-5 Emergency Escape Ramp

Emergency escape ramp is an important safety measure under safety management of long steep grades. They are extensively used on primary roads of the AH network in China e.g. AH3, AH14 in Yunnan Province. Their use is specific to geography and road design. In the design standard, emergency escape ramps will be included.

H-6 Emergency Telephones

Emergency telephones are generally provided on primary roads. Their need is much reduced with the widespread ownership of mobile phones. Their use is now more restricted to special managed road sections, notably tunnels and major bridges. The topic is generally covered under ITS but their relationship with fixed facilities e.g. chainage markers, laybys, safety barrier openings etc. could be covered in the design standard.

10. Conclusions and Recommendation

Through review of literature, consideration of results of the survey conducted in the Asian Highway member countries, star rating scenario testing of selected road infrastructure safety facilities, inputs received from the participating member countries and detailed review and analyses of the existing design standards and guidelines in the member countries and international sources, the following conclusions are drawn:

(i) The study showed that compared to the samples of standards and guides reviewed, the Annex II to the Intergovernmental Agreement on the Asian Highway Network covers limited number of road infrastructure safety facilities. The Annex II to the Intergovernmental Agreement on the Asian Highway network provides inadequate details and contemporary thinking about road safety. In relation to road safety, for example, it includes only one very general reference, simply saying:
While developing the Asian Highway network, Parties shall give full consideration to issues of safety (Paragraph 10, Section III of Annex II).

(ii) The international road assessment programme (iRAP) methodology was used to illustrate how relative risk levels for vehicle occupants, motorcyclists, pedestrians and bicyclists would change if a range of road infrastructure safety facilities were added to the existing Asian Highway standard (Table 4 of Annex II). The analysis result shows that, with some exceptions, the Star Ratings for the existing Asian Highway Standards as stipulated in the Annex II to the Agreement, the 'baseline' scenarios are in the high risk 1- and 2-star ranges. This reflects a combination of very limited infrastructure provision that is specified in the Asian Highway design standards and, especially in the Level and Rolling terrain classes, at relatively high speeds. Without exception, the addition of road infrastructure safety facilities results in reductions in risk. Overall, this analysis indicates that achieving a minimum of a 3-star rating for all road users on the Asian Highway network is feasible through the application of a range of reasonable well-known road infrastructure safety facilities that could be included in the Asian Highway design standards as a new Annex.

(iii) The results of the survey responses received from 17 Asian Highway member countries show that all the 36 road infrastructure safety facilities are used in at least one member country. It is unsurprising that the road infrastructure safety facilities most commonly present on the Asian Highway routes are those which are perceived to be most effective. The results suggest that there is potential to promote the use of a broader range of road infrastructure safety facilities on the Asian Highway network; just 10 of the countries use more than half of the 36 road infrastructure safety facilities. The results also suggest that a rapid take up of internationally well-used road infrastructure

safety facilities would be necessary. The questionnaire identifies a number of reasons that particular road infrastructure safety facilities are not used, including lack of planning and/or design (23%), lack of budget (12%), not cost effective (7%) and other reasons (33%). Apart from developing regional standards to support design and implementation of a broader range of road infrastructure safety facilities, these survey results suggest that case studies to support the use of each road infrastructure safety facility and training on use of them may be helpful in removing perceived barriers to their uses.

(iv) The Intergovernmental Agreement on the Asian Highway Network developed under the auspices of ESCAP secretariat provides an institutional platform for providing guidance to member countries in many areas and could further be used for promoting a coordinated approach to the development and adoption of standards of road infrastructure safety facilities along the routes of the Asian Highway network. There is an urgent need for the member countries to adopt and implement technical design standards of road infrastructure safety facilities for the Asian Highway network. In this regard, two different draft documents have been prepared. The first document consists of the proposed minimum design standards of road infrastructure safety facilities for the Asian Highway Network known as “Asian Highway Design Standards for Road Safety”. This document could serve as draft Annex II bis to the Intergovernmental Agreement on the Asian Highway network. The second document included in is a comprehensive related detailed “Design Guideline” of road infrastructure safety facilities which could serve as a recommended practice for the Asian Highway network.

In consideration of the above conclusions drawn in the study and as explained in the previous chapters of this report, the following recommendations are made:

(i) The Asian Highway member countries are recommended to consider the road safety as a priority in planning, designing, constructing, maintaining and managing the Asian Highway routes. As road infrastructure safety facilities can play a vital role in improving road safety, it is strongly recommended to adopt and practice technical design standards of road infrastructure safety facilities.

(ii) The study emphasizes on providing guidance to the Asian Highway member countries through a dedicated new annex to the Intergovernmental Agreement on the Asian Highway network. The draft new “Annex II bis” is recommended for consideration by the Asian Highway member countries towards adoption as minimum technical standards of road infrastructure safety facilities for the Asian Highway Network. The related design guidelines included at the end of this report is recommended to be used as a reference document for the Asian Highway Network.

Appendix A: Road Design Standards and Guides Cited (Literature Review)

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
China	Guide for Implementation of Improve Highway Safety to Cherish the Life Project (Provisional, in Chinese only, requires purchase)	Research Institute of Highways and Guizhou Provincial Department of Transport	2015/02/01	Nil
China	JTG B01-2003 Technical Standard of Highway Engineering (requires purchase)	Ministry of Transport	2004	http://www.codeofchina.com/ps/jt/8536.html (English version on sale)
China	JTG/T D21-2014 Guidelines for Design of Highway Grade-separated Intersection (in Chinese only, requires purchase)	Ministry of Transport	2014	Nil
China	JTG D81-2006 Guidelines for Design of Highway Safety Facilities (in Chinese only, requires purchase)	Ministry of Transport	2006	Nil
China	JTG D20-2006 Design Specification for Highway Alignment (in Chinese only, requires purchase)	Ministry of Transport	2006	Nil
China	JTG D82-2009 Specification for Layout of Highway Traffic Signs and Markings (in Chinese only, requires purchase)	Ministry of Transport	2009	Nil
China	JTG/T B05-2004 Guidelines for Safety Audit of Highway (recommended standard, in Chinese only, requires purchase)	Ministry of Transport	2004	Nil
China	JTG/T D71-2004 Draft Specification for Traffic Engineering of Highway Tunnel (in Chinese only, requires purchase)	Ministry of Transport	2004	Nil

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
Hong Kong, China	Transport Planning and Design Manual Volume 2 Highway Design Characteristics	Transport Department	Varies with chapters	http://ebook.lib.hku.hk/HKG/B35821449V2.pdf
Hong Kong, China	Transport Planning and Design Manual Volume 5 Accident Investigation and Prevention	Transport Department	Varies with chapters	http://ebook.lib.hku.hk/HKG/B35821449V2.pdf
Hong Kong, China	Guidelines for Design of End-Details for Thrie-Beam Barrier Fence RD/GN/040	Highways Department	2013/09/01	http://www.hyd.gov.hk/en/publications_and_publicity/publications/technical_document/guidance_notes/pdf/GN040.pdf
Hong Kong, China	Supplementary Guidelines for Design of End-details for W-beam and Concrete Profile Barriers	Highways Department	2013/09/01	http://www.hyd.gov.hk/en/publications_and_publicity/publications/technical_document/guidance_notes/pdf/GN040_supp.pdf
Hong Kong, China	Structures Design Manual for Highways and Bridges	Highways Department	2013/05/01	http://www.hyd.gov.hk/en/publications_and_publicity/publications/technical_document/structures_design_manual_2013/index.html
Hong Kong, China	Guidance Notes on Road Surface Requirements for Expressways and High Speed Roads	Highways Department	2007/06/01	http://www.hyd.gov.hk/en/publications_and_publicity/publications/technical_document/guidance_notes/pdf/GN032.pdf
Hong Kong, China	Guidance Notes on Installation of Barriers at Emergency Crossings and Contingency Crossing in Central Divider of Dual Carriageway RD/GN/34A	Highways Department	2010/09/01	http://www.hyd.gov.hk/en/publications_and_publicity/publications/technical_document/guidance_notes/pdf/GN034a.pdf

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
Hong Kong, China	Guidance Notes on Installation of Barriers at Emergency Crossings and Contingency Crossing in Central Divider of Dual Carriageway RD/GN/34A	Highways Department	2010/09/01	http://www.hyd.gov.hk/en/publications_and_publicity/publications/technical_document/guidance_notes/pdf/GN034a.pdf
Hong Kong, China	Code of Practice for the Lighting, Signing and Guarding of Road Works	Highways Department	2006	http://www.hyd.gov.hk/en/publications_and_publicity/publications/technical_document/code_of_practice/index.html
Hong Kong, China	Public Lighting Design Manual	Highways Department	2006	http://www.hyd.gov.hk/en/publications_and_publicity/publications/technical_document/public_lighting_design_manual/index.html
Georgia	SST Gzegi:2009 Georgia Road Design Standards	LEPL National Agency for Standards	2009	Road Department of Georgia: http://www.mrdi.gov.ge/en/news/page/52aef8030cf260af4f9cf49d
Kazakhstan	Highway Design Standards, 1998 {Developed with ADB technical assistance and the cooperation of Kazakhstan, Kyrgyzstan, Uzbekistan and Mongolia in June 1998}	Department of Roads, Kazakhstan	1998	http://www.adb.org/sites/default/files/project-document/72078/30523-reg-tcr.pdf
Kyrgyzstan	Highway Design Standards, 1998 {Developed with ADB technical assistance and the cooperation of Kazakhstan, Kyrgyzstan, Uzbekistan and Mongolia in June 1998}	Directorate General for Rehabilitation and Maintenance of Roads, Kyrgyzstan	1998	http://www.adb.org/sites/default/files/project-document/72078/30523-reg-tcr.pdf

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
Mongolia	Highway Design Standards, 1998 {Developed with ADB technical assistance and the cooperation of Kazakhstan, Kyrgyzstan, Uzbekistan and Mongolia in June 1998}	Department of Roads, Mongolia	1998	http://www.adb.org/sites/default/files/project-document/72078/30523-reg-tcr.pdf
Russian Federation (the)	SNiP 2.05.02-85, Design Standard for Highways	SNiP	2004	http://oneroads.ru/free/snip_2.05.02-08.pdf
Uzbekistan	Highway Design Standards, 1998 {Developed with ADB technical assistance and the cooperation of Kazakhstan, Kyrgyzstan, Uzbekistan and Mongolia in June 1998}	Directorate General for Rehabilitation and Maintenance of Roads, Uzbekistan	1998	http://www.adb.org/sites/default/files/project-document/72078/30523-reg-tcr.pdf
Indonesia	Indonesian Highway Capacity Manual Part I - Urban Roads	Ministry of Public Works	33970	https://nursyamsu05.files.wordpress.com/2012/04/ihcm-urban-road-part-1-5.pdf
Indonesia	Indonesian Highway Capacity Manual Part II - Interurban Roads	Ministry of Public Works	34700	https://nursyamsu05.files.wordpress.com/2012/04/ihcm-interurban-road-part-6-7.pdf
Indonesia	Indonesian Road Design Manual	Being prepared in a world bank's project??	0	0
Singapore	Chapter 10 of Civil Design Criteria for Road and Rail Transit Systems E/GD/09/106/A1	Land Transport Authority	40210	http://www.lta.gov.sg/content/dam/ltaweb/corp/Industry/files/DC_EGD09106A1_Overall.pdf
Singapore	COP for works on public street	0	41852	http://www.lta.gov.sg/content/dam/ltaweb/corp/Industry/files/COP%20for%20Works%20on%20Public%20Streets_Aug%202014%20R8a.pdf
Thailand	Traffic Engineering (Thai)	0	0	0
Thailand	Standard Traffic Signs (Thai)	0	0	0

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
Philippines (the)	Highway Safety Design Standards Part 1: Road Safety Design Manual	Department of Public Works and Highways	41030	http://www.dpwh.gov.ph/pdf/road%20safety%20manuals%202012.zip
Philippines (the)	Highway Safety Design Standards Part 2: Road Signs and Pavement Markings Manual	Department of Public Works and Highways	41030	http://www.dpwh.gov.ph/pdf/road%20safety%20manuals%202012.zip
Bangladesh	Geometric Design Standards for Roads & Highways Department	Ministry of Communications Roads and Railways Division	36800	http://www.rhd.gov.bd/Documents/ConvDocs/Road%20Geometric%20Design%20Manual.pdf
Bangladesh	Road Sign Manual Volume 1	Bangladesh Road Transport Authority Ministry of Communication	36586	http://www.rhd.gov.bd/Documents/ConvDocs/Road%20Sign%20Manual%20Volume-1.pdf
Bangladesh	Road Sign Manual Volume 2	Bangladesh Road Transport Authority Ministry of Communication	36586	http://www.rhd.gov.bd/Documents/ConvDocs/Road%20Sign%20Manual%20Volume-2.pdf
Bhutan	Guidelines on Road Classification System and Delineation of Construction and Maintenance Responsibilities	Royal Government of Bhutan, Ministry of Works & Human Settlement	2009	http://www.mowhs.gov.bt/wp-content/uploads/2010/11/English_Road_Guidelines.pdf
Bhutan	Draft Pavement Markings Manual	Royal Government of Bhutan, Ministry of Works & Human Settlement	39295	0
Bhutan	Draft Road Signs Manual	Royal Government of Bhutan, Ministry of Works & Human Settlement	39295	0
Bhutan	Road Safety Audit Policies and Toolkit	Royal Government of Bhutan, Ministry of Works & Human Settlement	39052	0
Bhutan	Survey & Design Manual	Royal Government of Bhutan, Ministry of Works & Human Settlement	-	0

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
India	IRC : 73 Geometric Design of Rural (non-Urban) Highway	Indian Roads Congress	1980	http://www.civilisco des.blogspot.hk/sear ch/label/IRC%2073% 20- %201980%20GEOME TRIC%20DESIGN%20 OF%20RURAL%20RO ADS
India	Street Design Guidelines	Delhi Development Authority, New Delhi	40483	http://www.uttipec.n ic.in/StreetGuidelines -R1-Feb2011- UTTPEC-DDA.pdf
India	IRC : 79-1981 Recommended Practice for Road Delineators	The Indian Road Congress	0	0
India	IRC : 35-1997 Code of Practice for Road Markings (First Revision)	The Indian Road Congress	35643	http://www.manune ethi.in/FILES/IRC%20 CODES%20&%20MO RTH%20SPECIFICATI ONS/IRC-35- (Road%20markings% 20Ist%20revision%20 code%20of%20practi ces).pdf
India	IRC : 66-1976 Recommended Practice for Sight Distance on Rural Highways	The Indian Road Congress	28004	http://www.civilisco des.blogspot.hk/sear ch/label/IRC%2066% 20- %201976%20RECOM MENDED%20PRACTI CE%20FOR%20SIGHT %20DISTANCE%20FO R%20RURAL%20HIG HWAYS
India	IRC : 86-1983 Geometric Design Standards for Urban Roads in Plains	The Indian Road Congress	30529	http://www.civilisco des.blogspot.hk/sear ch/label/IRC%2086% 201983%20GEOMET RIC%20DESIGN%20S TANDARDS%20FOR% 20URBAN%20ROADS %20IN%20PLAINS
Nepal	Nepal Road Standard 2070	Department of Roads	41456	http://www.dor.gov. np/documents/Nepal %20Road%20Standar d%20-2070.pdf
Nepal	Road Safety Notes 2 Designing Safer Side Drains	Ministry of Works and Transport	35370	http://www.dor.gov. np/documents/2%20 Designing%20Safer% 20Side%20Drains.pdf

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
Nepal	Road Safety Notes 5 Delineation Measures	Ministry of Works and Transport	35125	http://www.dor.gov.np/documents/5%20Delineation%20Measures.pdf
Nepal	Road Safety Notes 6 Safety Barrier	Ministry of Works and Transport	35612	http://www.dor.gov.np/documents/6%20Safety%20Barrier.pdf
Nepal	Traffic Signs Manual Volume 1 of 2	Department of Roads	35643	http://www.dor.gov.np/documents/traffic%20signs%201.pdf
Afghanistan	Rural Road Manual	Ministry of Rural Rehabilitation and Development	2013	http://mrrd.gov.af/Content/files/Rural%20Roads%20Manual.pdf
Iran (Islamic Republic of)	Guidelines for Geometry Design of Highway, Standard of Iran	Standard of Iran	0	Iranian National Standard - http://www.isiri.org/Portal/Home/
Turkey	Highway Design Manual	General Directorate of Highways [KGM]	2005	KGM - http://www.kgm.gov.tr/Sayfalar/KGM/SiteEng/Root/MainPageEnglish.aspx
Norway	Manual N101E: Vehicle Restraint Systems - and Roadside Areas	Norwegian Public Roads Administration Manual	41791	http://www.vegvesen.no/_attachment/393502/binary/968120?fast_title=Manual+N101E+Vehicle+Restraint+Systems+and+Roadside+Areas.pdf
Norway	Manual R310E: Road Traffic Safety Equipment	Norwegian Public Roads Administration Manual	41791	http://www.vegvesen.no/_attachment/194594/binary/964076?fast_title=Manual+R310E+Road+traffic+safety+equipment.pdf
Norway	Manual V720E: Road Safety Audits and Inspections	Norwegian Public Roads Administration Manual	41791	http://www.vegvesen.no/_attachment/61483/binary/968121?fast_title=Manual+V720E+Road+Safety+Audits+and+Inspections.pdf
United Kingdom of Great Britain and Northern Ireland	Requirements for Road Restraint Systems (Design Manual for Roads and Bridges TD19/06)	Highways England	38930	http://www.standardsforhighways.co.uk/dmrb/vol2/section2/td1906.pdf

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
United Kingdom of Great Britain and Northern Ireland	BD 78/99 Design of Road Tunnels	Highways England	1999	http://www.standardsforhighways.co.uk/dmrb/vol2/section2/bd7899.pdf
United Kingdom of Great Britain and Northern Ireland	Safety Aspects of Road Edge Drainage Features HA 83/99 (Design Manual for Roads and Bridges)	Highways England	0	http://www.standardsforhighways.co.uk/dmrb/vol4/section2/ha8399.pdf
United Kingdom of Great Britain and Northern Ireland	Road Safety Audit HD 19/15 (Design Manual for Roads and Bridges)	Highways England	42036	http://www.standardsforhighways.co.uk/dmrb/vol5/section2/hd1915.pdf
United Kingdom of Great Britain and Northern Ireland	Provisions for Non-motorised Users TA 91/05 (Design Manual for Roads and Bridges)	Highways England	38384	http://www.standardsforhighways.co.uk/dmrb/vol5/section2/ta9105.pdf
United Kingdom of Great Britain and Northern Ireland	Non-motorised Users Audit HD 42/05 (Design Manual for Roads and Bridges)	Highways England	38384	http://www.standardsforhighways.co.uk/dmrb/vol5/section2/hd4205.pdf
United Kingdom of Great Britain and Northern Ireland	Highway Link Design TD 9/93 (Design Manual for Roads and Bridges)	Highways England	37288	http://www.standardsforhighways.co.uk/dmrb/vol6/section1.htm
United Kingdom of Great Britain and Northern Ireland	Cross-Section and Headrooms TD 27/05 (Design Manual for Roads and Bridges)	Highways England	2005	http://www.standardsforhighways.co.uk/dmrb/vol6/section1.htm
United Kingdom of Great Britain and Northern Ireland	Guidance on Minor Improvements to Existing Roads TA 85/01 (Design Manual for Roads and Bridges)	Highways England	2001	http://www.standardsforhighways.co.uk/dmrb/vol6/section1.htm
United Kingdom of Great Britain and Northern Ireland	Design of Wide Single 2+1 Roads TD 70/08 (Design Manual for Roads and Bridges)	Highways England	2008	http://www.standardsforhighways.co.uk/dmrb/vol6/section1.htm
United Kingdom of Great Britain and Northern Ireland	TD 22/06 Layout of Grade-separated Junctions (Design Manual for Roads and Bridges)	Highways England	2006	http://www.standardsforhighways.co.uk/dmrb/vol6/section2.htm
United Kingdom of Great Britain and Northern Ireland	TD 54/07 Design of Mini-roundabouts (Design Manual for Roads and Bridges)	Highways England	2007	http://www.standardsforhighways.co.uk/dmrb/vol6/section2.htm

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
United Kingdom of Great Britain and Northern Ireland	TD 16/07 Geometric Design of Roundabouts (Design Manual for Roads and Bridges)	Highways England	2007	http://www.standardsforhighways.co.uk/dmrb/vol6/section2.htm
United Kingdom of Great Britain and Northern Ireland	TD 78/97 Design of Road Markings at Roundabouts (Design Manual for Roads and Bridges)	Highways England	1997	http://www.standardsforhighways.co.uk/dmrb/vol6/section2.htm
United Kingdom of Great Britain and Northern Ireland	TD 50/04 The Geometric Layout of Signal-Controlled Junctions and Signalised Roundabouts (Design Manual for Roads and Bridges)	Highways England	2004	http://www.standardsforhighways.co.uk/dmrb/vol6/section2.htm
United Kingdom of Great Britain and Northern Ireland	TD 39/94 The Design of Major Interchanges (Design Manual for Roads and Bridges)	Highways England	1994	http://www.standardsforhighways.co.uk/dmrb/vol6/section2.htm
United Kingdom of Great Britain and Northern Ireland	TD 40/94 Layout of Compact Grade Separated Junctions (Design Manual for Roads and Bridges)	Highways England	1994	http://www.standardsforhighways.co.uk/dmrb/vol6/section2.htm
United Kingdom of Great Britain and Northern Ireland	TD 42/95 Geometric Design of Major/Minor Priority Junctions (Design Manual for Roads and Bridges)	Highways England	1995	http://www.standardsforhighways.co.uk/dmrb/vol6/section2.htm
United Kingdom of Great Britain and Northern Ireland	TD 41/95 Vehicular Access to All-Purpose Trunk Roads	Highways England	1995	http://www.standardsforhighways.co.uk/dmrb/vol6/section2.htm
United Kingdom of Great Britain and Northern Ireland	TA 86/03 Layout of Large Signal-Controlled Junctions (Design Manual for Roads and Bridges)	Highways England	2003	http://www.standardsforhighways.co.uk/dmrb/vol6/section2.htm
United Kingdom of Great Britain and Northern Ireland	TD 36/93 Subways for Pedestrians and Pedal Cyclists Layout and Dimensions (Design Manual for Roads and Bridges)	Highways England	1993	http://www.standardsforhighways.co.uk/dmrb/vol6/section3.htm

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
United Kingdom of Great Britain and Northern Ireland	TD 69/07 The Location and Layout of Laybys and Rest Areas (Design Manual for Roads and Bridges)	Highways England	2007	http://www.standardsforhighways.co.uk/dmrb/vol6/section3.htm
United Kingdom of Great Britain and Northern Ireland	TA 81/99 Coloured Surfacing in Road Layout (Excluding Traffic Calming) (Design Manual for Roads and Bridges)	Highways England	1999	http://www.standardsforhighways.co.uk/dmrb/vol6/section3.htm
United Kingdom of Great Britain and Northern Ireland	TD 51/03 Segregated Left Turn Lanes and Subsidiary Deflection Islands at Roundabouts (Design Manual for Roads and Bridges)	Highways England	2003	http://www.standardsforhighways.co.uk/dmrb/vol6/section3.htm
United Kingdom of Great Britain and Northern Ireland	TA 87/04 Trunk Road Traffc Calming (Design Manual for Roads and Bridges)	Highways England	2004	http://www.standardsforhighways.co.uk/dmrb/vol6/section3.htm
United Kingdom of Great Britain and Northern Ireland	TA 90/05 The Geometric Design of Pedestrian, Cycle and Equestrian Routes (Design Manual for Roads and Bridges)	Highways England	2005	http://www.standardsforhighways.co.uk/dmrb/vol6/section3.htm
United Kingdom of Great Britain and Northern Ireland	TA 98/08 The Layout of Toll Plazas (Design Manual for Roads and Bridges)	Highways England	2008	http://www.standardsforhighways.co.uk/dmrb/vol6/section3.htm
United Kingdom of Great Britain and Northern Ireland	Traffic Signs Manuals	Department for Transport	Varies	http://tsrgd.co.uk/documents/traffic-signs-manual
United Kingdom of Great Britain and Northern Ireland	Traffic Signs Manuals	Department for Transport	2009	http://tsrgd.co.uk/documents/traffic-signs-manual
United Kingdom of Great Britain and Northern Ireland	HD 28/04 Skid Resistance (Design Manual for Roads and Bridges)	Highways England	2004	http://www.standardsforhighways.co.uk/dmrb/vol7/section3/hd2804.pdf
United Kingdom of Great Britain and Northern Ireland	Safety at Street Works and Road Works A Code of Practice	Department for Transport	41548	http://tsrgd.co.uk/pdf/sw/sw2013.pdf
United Kingdom of Great Britain and Northern Ireland	Setting Local Speed Limits	Department for Transport	2013	https://www.gov.uk/government/publications/setting-local-speed-limits

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
United Kingdom of Great Britain and Northern Ireland	Designing Safer Roadsides - A Handbook for Highway Engineers	Passive Safety UK in association with Traffic Engineering & Control	39569	http://www.ukroads.org/webfiles/handbook_flyer.pdf
United Kingdom of Great Britain and Northern Ireland	Design & Maintenance Guidance for Local Authority Roads - Provision of Road Restraint Systems on Local Authority Roads	Department for Transport, UK Roads Liaison Group	40817	http://www.ukroadsliaisongroup.org/en/utilities/document-summary.cfm?docid=5803F825-EFC0-4858-B2A75D0DCE3382A9
United Kingdom of Great Britain and Northern Ireland	Passive Safety UK Guidelines for Specification and Use of Passively Safe Street Furniture on the UK Road Network	Passive Safety UK in association with Traffic Engineering & Control	40269	http://www.ukroads.org/webfiles/Guidelines%20Print%20ready.pdf
United Kingdom of Great Britain and Northern Ireland	The Use of Passively Safe Signposts and Lighting Columns	County Surveyors Society with Transport Research Laboratory	39661	https://www.theilp.org.uk/documents/css-sl4-passive-safety/
United Kingdom of Great Britain and Northern Ireland	Guidelines for Motorcycling	Institute of Highway Engineers	2005 with updates	http://www.motorcycleguidelines.org.uk/#
France	National Instruction on Technical Design Requirements for Rural Motorways (ICTAAL)	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	36861	http://www.infra-transports-materiaux.cerema.fr/IMG/pdf/US_ICTAAL_GB.pdf
France	Amenagement des Routes Principales (ARP) - Guide Technique (in French only, require purchase)	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	34547	http://catalogue.setra.fr/resultsframe.xsp?q=&log=true&t2=DT&t4=LO&t6=CA&t5=VI&sujet=amenagement+des+routes+principales&op_mots_sujet=and&domaine=0%7CTous&periode=1&A1=1969&A2=2015&sf=date&fenetre=1&submit=Afficher
France	The design of interurban intersections on major roads - At-grade intersections	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	36130	http://www.infra-transports-materiaux.cerema.fr/technical-guides-r781.html
France	Road Safety Inspections	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	39965	http://www.infra-transports-materiaux.cerema.fr/technical-guides-r781.html

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
France	Signing Bends	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	37438	http://www.infra-transports-materiaux.cerema.fr/technical-guides-r781.html
France	Improving the Safety of Bends on Major Rural Roads	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	37377	http://www.infra-transports-materiaux.cerema.fr/technical-guides-r781.html
France	Road Junction Improvement and Safety	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	35400	http://www.infra-transports-materiaux.cerema.fr/technical-guides-r781.html
France	Handling Lateral Obstacles on Main Roads in Open Country	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	39295	http://www.infra-transports-materiaux.cerema.fr/technical-guides-r781.html
France	Landscape and Road Legibility	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	38869	http://www.infra-transports-materiaux.cerema.fr/technical-guides-r781.html
France	Lutte Contre Les Prises à Contresens (Measures to Prevent Wrong Way Travel, in French only)	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	40422	http://www.infra-transports-materiaux.cerema.fr/IMG/pdf/1034w_NI_CSEE_134.pdf
France	L'aménagement d'une Traversée d'agglomération (Design of Highway Traversing Settlements, in French only, requires purchase)	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	40269	http://www.cerema.fr/
France	Descentes de Forte Pente et de Grande Longueur sur Les Routes de Type Autoroute (Long Steep Descent on Expressway, in French only)	Centre of Study and Expertise on Risks, Environment, Mobility and Design (Cerema), France	35462	http://dtrf.setra.fr/pdf/pj/Dtrf/0000/Dtrf-0000742/DT742.pdf?openerPage=results&qid=sdx_q0
0	Long Steep Grade	0	0	0
Australia	Guide to Road Design	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
Australia	Guide to Road Design - DRAINAGE SET	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD-DRAIN
Australia	Guide to Road Design Part 1: Introduction to Road Design	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD01-10
Australia	Guide to Road Design Part 2: Design Considerations	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD02-06
Australia	Guide to Road Design Part 3: Geometric Design	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD03-10
Australia	Guide to Road Design Part 4: Intersections and Crossings – General	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD04-09
Australia	Guide to Road Design Part 4A: Unsignalised and Signalised Intersections	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD04A-10
Australia	Guide to Road Design Part 4B: Roundabouts	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD04B-11
Australia	Guide to Road Design Part 4C: Interchanges	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD04C-09
Australia	Guide to Road Design Part 5: Drainage – General and Hydrology Considerations	0	0	https://www.onlinepublications.austroads.com.au/items/AGRD05-13
Australia	Guide to Road Design Part 5A: Drainage – Road Surface, Networks, Basins and Subsurface	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD05A-13
Australia	Guide to Road Design Part 5B: Drainage – Open Channels, Culverts and Floodways	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD05B-13
Australia	Guide to Road Design Part 6: Roadside Design, Safety and Barriers	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD06-10

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
Australia	Guide to Road Design Part 6A: Pedestrian and Cyclist Paths	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD06A-09
Australia	Guide to Road Design Part 6B: Roadside Environment	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD06B-09
Australia	Guide to Road Design Part 7: Geotechnical Investigation and Design	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD07-08
Australia	Guide to Road Design Part 8: Process and Documentation	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRD08-09
Australia	Austroads Design Vehicles and Turning Path Templates	Austroads	0	https://mail.google.com/mail/u/0/#inbox/14e9b7d6ce17e3df
Australia	Cycling Aspects of Austroads Guides (2014)	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AP-G88-14
Australia	Guide to Road Safety — SET	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRS
Australia	Guide to Road Safety Part 1: Road Safety Overview	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRS01-13
Australia	Guide to Road Safety Part 2: Road Safety Strategy and Evaluation	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRS02-13
Australia	Guide to Road Safety Part 3: Speed Limits and Speed Management	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRS03-08
Australia	Guide to Road Safety Part 4: Local Government and Community Road Safety	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRS04-09
Australia	Guide to Road Safety Part 5: Road Safety for Rural and Remote Areas	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRS05-06
Australia	Guide to Road Safety Part 6: Road Safety Audit	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRS06-09

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
Australia	Guide to Road Safety Part 7: Road Network Crash Risk Assessment and Management	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRS07-06
Australia	Guide to Road Safety Part 8: Treatment of Crash Locations	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRS08-09
Australia	Guide to Road Safety Part 9: Roadside Hazard Management	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AGRS09-08
Australia	Assessing Fitness to Drive for Commercial and Private Vehicle Drivers	Austroads	0	https://www.onlinepublications.austroads.com.au/items/AP-G56-13
UNESCAP	Asian Highway Classification and Design Standard	UNESCAP	34304	http://www.unescap.org/sites/default/files/AH%20classification%20and%20design%20standards-English.pdf
PIARC	Road Safety Audit Guidelines for Safety Checks of New Road Projects	PIARC World Road Federation	2011	http://www.piarc.org/en/publications/technical-reports/?catalog-topic=32&catalog-size=10&catalog-sort=date&catalog-offset=0&=OK
PIARC	Sustainable Interurban Roads for Tomorrow	PIARC World Road Federation	2009	http://www.piarc.org/en/publications/technical-reports/?catalog-topic=32&catalog-size=10&catalog-sort=date&catalog-offset=0&=OK
PIARC	PIARC Catalogue of Design Safety Problems and Potential Countermeasures	PIARC World Road Federation	2009	http://www.piarc.org/en/publications/technical-reports/?catalog-topic=32&catalog-size=10&catalog-sort=date&catalog-offset=0&=OK

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
PIARC	Human Factors Guidelines for Safer Road Infrastructure	PIARC World Road Federation	2008	http://www.piarc.org/en/publications/technical-reports/?catalog-topic=32&catalog-size=10&catalog-sort=date&catalog-offset=0&=OK
PIARC	Human Factors in Road Design. Review of Design Standards in Nine Countries.	PIARC World Road Federation	2012	http://www.piarc.org/en/publications/technical-reports/?catalog-topic=27&catalog-size=10&catalog-sort=date&catalog-offset=0&=OK
PIARC	Road Accident Investigation Guidelines for Road Engineers.	PIARC World Road Federation	2013	http://www.piarc.org/en/publications/technical-reports/?catalog-topic=27&catalog-size=10&catalog-sort=date&catalog-offset=0&=OK
PIARC	Road Safety Inspection Guidelines for Safety Checks of Existing Roads.	PIARC World Road Federation	2012	http://www.piarc.org/en/publications/technical-reports/?catalog-topic=27&catalog-size=10&catalog-sort=date&catalog-offset=0&=OK
PIARC	Improvements in Safe Working on Roads.	PIARC World Road Federation	2012	http://www.piarc.org/en/publications/technical-reports/?catalog-topic=27&catalog-size=10&catalog-sort=date&catalog-offset=0&=OK
ADB	Road Safety Guidelines for the Asian and Pacific Region	Asian Development Bank	2003	http://www.adb.org/sites/default/files/publication/29532/road-safety-guidelines.pdf
ADB	Road Safety Audit for Road Projects - An Operational Tool Kit	Asian Development Bank	37773	http://www.irfnet.ch/files-upload/member_area-pdf-files/RS_WG/Annex/Road-Safety-Audit-for-Road-Projects.pdf

Country / Province / Organization	Document title	Author(s)	Publication date	Web address
United States of America	Roadside Design Guide 4th Edition	AASHTO	2011	https://bookstore.transportation.org/collection_detail.aspx?ID=105
United States of America	A Policy on Geometric Design of Highways and Streets, 6th Edition	AASHTO	2011	https://bookstore.transportation.org/collection_detail.aspx?ID=110
United States of America	AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities, 1st Edition	AASHTO	2004	https://bookstore.transportation.org/collection_detail.aspx?ID=131
United States of America	Guide for the Development of Bicycle Facilities, 4th Edition	AASHTO	2012	https://bookstore.transportation.org/collection_detail.aspx?ID=116

Appendix B: Inputs from the National Experts of the Participating Countries

In parallel to the literature review, discussion on facilities to be included in the AH standards, the Asian Highway member country and Star Rating testing, the ESCAP Secretariat engaged national consultants in Bangladesh, China, India, the Republic of Korea and Thailand to provide additional information on the overall road safety situation in their country and road infrastructure facilities. These reports, listed and summarised below provided a valuable resource for the further development of the AH design standard.

Reports Received from the Participating Countries

Bangladesh:

- Noor-e-Alam, December 2015. *Final Report on Road Safety Infrastructure Facilities & Basic Information/data on Road Infrastructure Design Practices/Guidelines in Bangladesh.*
- Noor-e-Alam, December 2015. *Road Safety Infrastructure Related Policy, Planning, Regulatory and Technology Related Overall Situation in Bangladesh*.
- Noor-e-Alam, July 2015. *Report on Design Standard Of Road Infrastructure Safety facilities in Bangladesh*.

China:

- Xiaojing Wang, June 2016. *China: The Design Standards and Available Specifications.*
- Xiaojing Wang, September 2016. China: The Design Standards and Available Specifications (Supplementary).
- Xiaojing Wang, 2016. *RS-1A: Existing Literature on Road Safety Infrastructure Facilities in China.*
- Xiaojing Wang, 2016. *RS-2: Overall situation of the road safety infrastructure practices in China.*

India:

- Tony Mathew, September 2016. *Report on Design Guidelines for Road Safety Infrastructure Facilities in India.*

Republic of Korea:

- *Manuals on Roads Safety Facilities in Republic of Korea.*
- *Sung-min Cho, December 2015. Current Status and the Guidelines of Road Safety Facilities in the Republic of Korea Rep.*

Thailand:

- *Literature review on Road Safety Infrastructure in Thailand.*
- *Overall Situation of Road Safety Infrastructures in Thailand.*
- *Untitled* (dealing with road infrastructure).

Summary of Reports

Each country has design standards for road infrastructure safety facilities, although these vary according to local regulatory settings.

Design standard of road Infrastructure safety facilities	**Bangladesh**	**China**	**India**	**Korea**	**Thailand**
Line marking	•	•	•		•
Chevron mark	•	•		•	•
Raised pavement mark	•	•	•	•	•
Flexible delineation posts	•	•			•
Roadside barrier	•	•	•		•
Median Barrier	•	•	•	•	•
Central hatching (painted median)	•				
Crash cushion with channelization	•		•	•	
Safety barrier end treatment	•	•		•	•
Clear zones	•				
Centerline / edge line rumble strip	•		•	•	
Pedestrian crossing	•	•	•		•
Sidewalk (footpath)	•	•	•		•
Pedestrian fences	•				
Pedestrian refuge island	•	•			•
Protected turn lane (pocket lane for turning)	•	•			•
Intersection channelization	•				
Speed hump	•				
Visual traffic calming	•				
Automatic regulation camera	•				
Bicycle lane	•				
Exclusive motorcycle lane	•				
Lighting	•	•	•		•
Sight distance	•	•		•	•
Road signs			•	•	
Cattle crossing			•		
Truck Lay-bys			•		
Bus bays			•		
Rest areas			•		
Emergency Escape Ramps				•	
Skid Resistance				•	
Rockfall prevention				•	

Bangladesh

Given the size of the country, road network and vehicle population, the number of road crashes in Bangladesh is one of the highest in the world. Despite Government-led efforts to address the road safety problems, there have been a number of challenges including the (lack of) leadership in implementing road safety, institutional weaknesses, professional capacity and expertise, resource

constraints, poor accident data recording system, lack of integration between concern agencies, lack of government and private partnership. Resolving these issues will enable Bangladesh can look towards building safer roads as well as maintaining safety on the roads.

Bangladesh' policy and regulatory framework for road safety comprises the following:

- Road safety infrastructure related policies:
    a. National Land Transport Policy, 2004
    b. National Integrated Multimodal Transport Policy (NIMTP), 2013
    c. The Motor Vehicles' Axle Load Control Station Policy, 2012
- Road safety infrastructure related plans:
    a. Road Master Plan by Roads and Highways Department (RHD)
    b. National Road Safety Strategic Action Plan 2014 – 2016 by National Road Safety Council
    c. Sixth Five Year Plan (SFYP), 2011-15
- Road safety infrastructure related regulation:
    a. The Highway Act, 1925:
    b. The Motor Vehicles Ordinance, 1983
- Institutional Arrangements:
    a. National Road Safety Council (NRSC)
    b. Cabinet Committee on Road Safety
    c. Accident Research Centre (ARC)
    d. Bangladesh Road Transport Authority (BRTA)
    e. Road safety division in Roads and Highways Department (RHD)
    f. Highway Police
    g. District Road Safety Committee (DRSC)
    h. Non – Government Organization (NGO) initiatives towards Road Safety
    i. Road Safety Voluntary & Advisory Group

China

A major issue for China is the intrinsic safety of a road. Once construction is complete, large scale changes are not allowed except where reconstruction or expansion is necessary. It is therefore crucial that road safety design is incorporated prior to construction.

Another issue is the road safety facilities, including road traffic signs, traffic road markings and road protection facilities. According to the development of standards and specifications of highway

engineering and design, road safety factors still lack attention, and the safety related studies and analysis of road geometric alignment design parameters and indicators, which can be used to determine values of specific indicators, has not been taken into adequate consideration. Furthermore, the application of specific indicators and parameters are still not in practice.

China has two key design standards:

1. The "Technical Standards of Highway Engineering (JTG B01-2014)" which classifies highways into five classes (Motorway, I-Class highway, II-Class highway, III-Class highway and IV-Class highway), and each class has a group of design speeds, the design speed is determined by road functions and topographical conditions; and
2. The "Road Traffic Signs and Markings (GB5768-2009)", the basic standards of road traffic signs and markings system. There are two major categories: national and local. This standard recently revised and draws on experiences from USA, the UK, Germany and Japan. Over 80% of signs are the same or similar to those used in the US and Europe.

The draft edition of "Design Specification for Highway Alignment" which has being revised also clearly clarifies that operating speed based design method shall be adopted for all classes of highway when geometric alignment design general plan is confirmed.

India

Poor safety features in road network is a common problem in India. This is partly due to the lack of awareness in road safety among the professionals who plan and design the road and partly due to the lack of guidelines to design a safe road network. Road safety audits and blackspot improvement schemes are not yet mainstream.

The Indian Roads Congress (IRC) publishes an extensive range of 'Manuals' that include the specifications and standards for road design and construction. These are gradually being updated to incorporate road safety principles consistent with international standards.

IRC is gradually updating guidelines to incorporate road safety into the design, and to make the road furniture consistent with international guidelines. The IRC also publish the 'Orange Book' on behalf of Ministry of Road Transport & Highways, which is the Specification for Road and Bridge Works. It is the authoritative guide for quality control of highway construction in India covering materials used in highway construction from earthworks to structures, traffic signs, road markings and street lighting.

State road agencies are responsible for design, construction and operation of state highways and other roads. Generally state road agencies follow guidelines published by IRC and MoRT&H, however, the extent of application of these guidelines on the ground is questionable.

Road safety is not well integrated into procurement practices for road design and construction.

Republic of Korea

In terms of traffic crashes and fatalities, the Republic of Korea is still behind the majority of OECD countries.

Responsibility for road safety in the Republic of Korea is shared among various ministries and agencies. These include:

- The Ministry of Land, Transport & Infrastructure is responsible for the national trunk road network of motorways and national highways.
- The responsibility for the National Expressways, the top-ranked arterial road network is entrusted to the Korea Expressway Corporation (KEC). KEC, a state-owned public corporation is the actual authority for the expressways.
- Local roads including City Roads and Provincial Roads are under the local government.
- Ministry of Public Safety & Security (MPSS) is responsible for safety of people and disaster management and has a safety management system.
- The National Police Agency is responsible for traffic enforcement and crash investigation. It also operates traffic signals, crossings and speed enforcement cameras.
- KoROAD is a government affiliated agency, supporting the National Police Agency, responsible for road traffic management. The agency is in charge of traffic monitoring, drivers' license examinations and management, training and education.

Guidelines and standards pertaining to Highway Safety are covered in the following documents:

- Expressway Design Manual, Chapter 12 (KEC)
- Guidelines on the Installation and Maintenance of a Road Safety Facility (MOLIT)
- Rules for the Road Structure & Facilities Standards (MOLIT)
- Guidelines on the Installation and Maintenance of a Road Safety Facility (MOLIT)
- Manual on the Installation and Maintenance of the Traffic Safety Signs (Korea National Police Agency)
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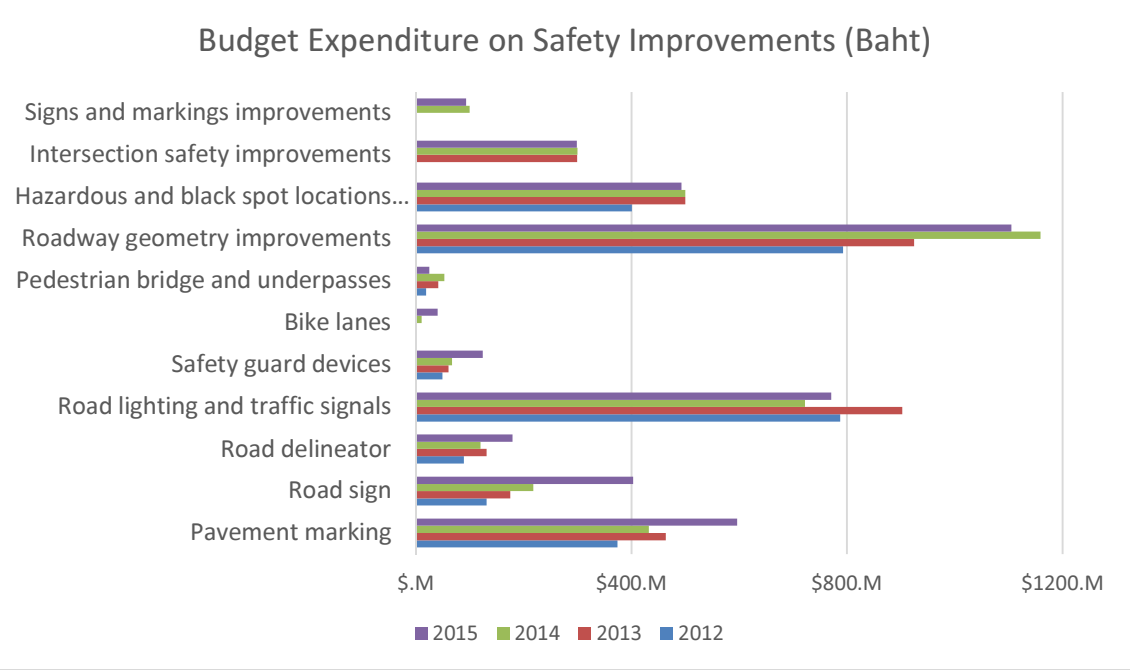
Thailand

Each year, there are new installations and maintenance operations of road safety infrastructures in Thailand. The vast majority of these are routine-type upgrades involving pavement marking, road

signs, road delineators, road lighting and traffic signals, and safety guard devices. A small number are improvement of roadway geometry, hazardous and black spot locations, intersection safety and signs and markings (as preparation for entering the ASEAN Economic Community). There are occasional projects involving the installation of bike lanes, pedestrian bridge and underpasses.



Appendix C: Standards/Guidelines/Manuals Cited in the Survey Replies

Row Labels	Country	Name
A-1. Line marking	Bangladesh	Traffic Signs Manual, March 2000, Bangladesh Road Transport Authority
	Cambodia	MPWT, Standards Traffic Control Devices
	China	Road Traffic Signs and Markings (GB5768-2009);JTG D81-2006 Specification for Design of Highway Safety Facilities; JTG/T D81-2006 Guidelines for Design of Highway Safety Facilities; Specification for Layout of Highway Traffic Signs and Markings (JTG D82-2009)
	DPR Korea	Law on Road Construction and Road Designing Standard
		Law on Road Construction and Road Designing Standard stimulates location, size, and color of line marking
	Georgia	A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, EN 13197, EN1423, EN1436, ГОСТ Р 51256-99, Georgian Low "about Traffic Movement" , The Georgian National StandardSST Gzebi:2009
	Nepal	TRAFFIC SIGNS MANUAL, Published by Department of Road
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	по ГОСТУ 13508-74 и ГОСТ 23457-86
	Thailand	Manual of Uniform Traffic Control Devices (Pavement Marking and Delineator), Department of Highways
	Turkey	Rood Signs Manual 1-2
	Viet Nam	QCVN:41
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	Set of Rules SP 34.13330.2012 related to highways
	India	IRC:35-2015
	Philippines	In accordance to the Department Orders and Manuals
A-2. Chevron mark	Bangladesh	Traffic Signs Manual, March 2000, Bangladesh Road Transport Authority
	Cambodia	MPWT, Standards Traffic Control Devices

Row Labels	Country	Name
	China	Road Traffic Signs and Markings (GB5768-2009);JTG D81-2006 Specification for Design of Highway Safety Facilities; JTG/T D81-2006 Guidelines for Design of Highway Safety Facilities; Specification for Layout of Highway Traffic Signs and Markings (JTG D82-2009)
	DPR Korea	Regulation on National standard and Road Traffic Marking
		Regulation on National standard and Road Traffic Marking stimulates types, size, manufacture, installation of chevron marking
	Georgia	ГОСТ Р 52 290—2004, Georgian Low "about Traffic Movement"
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	ГОСТ23457-86
	Thailand	Manual of Uniform Traffic Control Devices (Traffic Sign), Department of Highways
	Turkey	Rood Signs Manual 1-2
	Viet Nam	TC 83
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD. This TSODD regulates the rules of application of traffic signs, traffic lights deployment, deployment of protective fences and deployment of signal devices
	India	IRC:67-2012
	Philippines	In accordance to the Department Orders and Manuals
A-3. Raised pavement mark	Cambodia	MPWT, Standards Traffic Control Devices
	China	Road Traffic Signs and Markings (GB5768-2009);JTG D81-2006 Specification for Design of Highway Safety Facilities; JTG/T D81-2006 Guidelines for Design of Highway Safety Facilities; Specification for Layout of Highway Traffic Signs and Markings (JTG D82-2009)
	Georgia	ГОСТ Р 52 290—2004, Georgian Low "about Traffic Movement"

Row Labels	Country	Name
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Thailand	Manual of Uniform Traffic Control Devices (Pavement Marking and Delineator), Department of Highways
	Turkey	Rood Signs Manual 1-2
	Viet Nam	QCVN:41
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 50971-2011 This TSODD regulates the use of retro reflective road and about them, general technical requirements and rules for their application
	India	IRC:35-2015
	Philippines	In accordance to the Department Orders and Manuals
A-4. Flexible delineation posts	Bangladesh	Traffic Signs Manual, March 2000, Bangladesh Road Transport Authority
	Cambodia	MPWT, Standards Traffic Control Devices
	China	JTG/T D81-2006 Guidelines for Design of Highway Safety Facilities
	DPR Korea	Regulation on National standard and Road Traffic Marking
		Regulation on National standard and Road Traffic Marking stimulates size and method of installation of delineation posts
	Georgia	EN 12899-3:2007
	Tajikistan	СС-1, СС-15, СЭВсерия 3.503.1-89
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 50970-2011 This TSODD regulates the use of signaling columns on the roads and general technical requirements and rules for their application
	Philippines	In accordance to the Department Orders and Manuals
A-5. Colored lanes	Viet Nam	QCVN:41

Row Labels	Country	Name
	Russian Federation	Interstate standards (GOST) 32753-2014 governs rules on highways related to the colored non-slip mats (i.e pedestrian crossings) and general technical requirements and rules for their application
	Philippines	In accordance to the Department Orders and Manuals
B-1. Roadside barrier	Bangladesh	RHD Standard Drawings for Road Works
	Cambodia	MPWT, Standards Traffic Control Devices
	China	JTG D81-2006 Specification for Design of Highway Safety Facilities; JTJ 074—94 Specification for Design and Construction of Expressway Safety Appurtenances; JTG B05-01-2013 Standard for Safety Performance Evaluation of Highway Barriers
	DPR Korea	Law on Road Construction and Road Designing Standard
	Georgia	EN 1317
	Tajikistan	БР 100.30.15, БР 100.30.18, БР 100.45.15, БР 300.30.15 и другие
	Thailand	Standard Drawings for Highway Construction, Department of Highways
	Viet Nam	QCVN:41
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 52607-2006 This TSODD regulates the use of various types of protective barriers on highways and theirs general technical requirements.
	India	MoRTH Specifications for road & bridge works
	Philippines	In accordance to the Department Orders and Manuals
B-2. Median barrier	Bangladesh	RHD Standard Drawings for Road Works
	China	JTG D81-2006 Specification for Design of Highway Safety Facilities;JTJ 074—94 Specification for Design and Construction of Expressway Safety Appurtenances; JTG B05-01-2013 Standard for Safety Performance Evaluation of Highway Barriers
	DPR Korea	Law on Road Construction and Road Designing Standard
	Georgia	Only Concrete EN 1317

Row Labels	Country	Name
	Tajikistan	11-ДД/350-1,15-2,0-1,1 (У5), 11-ДД/400-1,15-2,0-1,1 (У6), 11-ДД/450-1,15-2,0-1,0 (У7
	Thailand	Standard Drawings for Highway Construction, Department of Highways
	Viet Nam	QCVN:41
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 52607-2006 This TSODD regulates the use of various types of protective barriers on highways and theirs general technical requirements.
	India	MoRTH Specifications for road & bridge works
	Philippines	In accordance to the Department Orders and Manuals
B-3. Slide to protect head light from opposite direction	China	JTG D81-2006 Specification for Design of Highway Safety Facilities;JTG/T D81-2006 Guidelines for Design of Highway Safety Facilities
	DPR Korea	Law on Road Construction and Road Designing Standard
	Georgia	EN 1317
	Tajikistan	ГОСТ23457-86
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	Interstate standards (GOST) 32838-2014 govern the regulation of highways related to the use of barriers and dazzle and their general technical requirements.
	India	MoRTH Specifications for road & bridge works
B-4. Central hatching (painted median)	Cambodia	MPWT, Standards Traffic Control Devices
	China	Road Traffic Signs and Markings (GB5768-2009)
	DPR Korea	Law on Road Construction and Road Designing Standard
	Georgia	EN 1317
	Tajikistan	ГОСТ23457-86
	Thailand	Manual of Uniform Traffic Control Devices (Pavement Marking and Delineator), Department of Highways

Row Labels	Country	Name
	Turkey	Rood Signs Manual 1-2
	Viet Nam	QCVN:41
	Russian Federation	Set of Rules SP 34.13330.2012 related to highways. State standard (GOST) nr. R 52289-2004 TSODD. This TSODD regulates the rules of application of traffic signs, traffic lights deployment, deployment of protective fences and deployment of signal devices
	India	IRC:35-2015
	Philippines	In accordance to the Department Orders and Manuals
B-5. Crash cushion with channelization	Cambodia	MPWT, Standards Traffic Control Devices
	Georgia	EN 1317
	Tajikistan	ГОСТ23457-86
	Viet Nam	TC 83
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	Interstate standards (GOST) 33127-2014 govern the regulation of highways related to the classification of the road fences.
	Philippines	In accordance to the Department Orders and Manuals
B-6. Safety barrier end treatment	Cambodia	MPWT, Standards Traffic Control Devices
	China	JTG/T D81-2006 Guidelines for Design of Highway Safety Facilities
	DPR Korea	Law on Road Construction and Road Designing Standard
	Georgia	EN 1317
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	ГОСТ26804-86
	Thailand	Standard Drawings for Highway Construction, Department of Highways
	Viet Nam	QCVN:41

Row Labels	Country	Name
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD. This TSODD regulates the rules of application of traffic signs, traffic lights deployment, deployment of protective fences and deployment of signal devices
	Philippines	In accordance to the Department Orders and Manuals
B-7. Clear zones	China	JTG D81-2006 Specification for Design of Highway Safety Facilities; Guideline for Implementation of Highway Safety Enhancement Project
	Georgia	A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001
	Tajikistan	ГОСТ26804-86
	Viet Nam	Design standards
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD. This TSODD regulates the rules of application of traffic signs, traffic lights deployment, deployment of protective fences and deployment of signal devices
C-1. Skid resistance (Anti-skid pavement)	China	JTG D50-2006 Specifications for Design of Highway Asphalt Pavement; Guide for Implementation of Improved Highway Safety to Cherish the Life Project (Tentative Standard)
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Viet Nam	Design standards
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	Interstate standards (GOST) 32753-2014 governs rules on highways related to the colored non-slip mats (i.e pedestrian crossings) and general technical requirements and rules for their application

Row Labels	Country	Name
C-2. Centerline / edge line rumble strip	Cambodia	MPWT, Standards Traffic Control Devices
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Viet Nam	QCVN:41
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	Interstate standards (GOST) 33025-2014 govern the regulation of highways related to the traffic lane with a high coefficient of friction (rustling) and its general technical requirements.
	Philippines	In accordance to the Department Orders and Manuals
D-1. Pedestrian crossings	Bangladesh	Traffic Signs Manual, March 2000, Bangladesh Road Transport Authority
	Cambodia	MPWT, Standards Traffic Control Devices
	China	Road Traffic Signs and Markings (GB5768-2009)
	DPR Korea	Law on Road Construction and Road Designing Standard
	Georgia	A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, ГОСТ Р 51256-99, Georgian Low "about Traffic Movement" ГОСТ 10807-78б ГОСТ 23457-8б ГОСТ Р 52 290—2004
		A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, ГОСТ Р 51256-99, Georgian Low "about Traffic Movement" ГОСТ 10807-78б ГОСТ 23457-8б ГОСТ Р 52 290—2004
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	по ГОСТУ 13508-74 и ГОСТ 23457-86
	Thailand	Standard Drawings for Highway Construction, Department of Highways
	Viet Nam	QCVN:41
	Republic of Korea	보도설치및관리지침_Guidelines for pedestrian facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD. This TSODD regulates the rules of application of traffic signs,

Row Labels	Country	Name
		traffic lights deployment, deployment of protective fences and deployment of signal devices
	India	IRC:103-1998
	Philippines	In accordance to the Department Orders and Manuals
D-2. Sidewalk (footpath)	Bangladesh	Roads and Highways Department Geometric Design
	Cambodia	MPWT, Standards Traffic Control Devices
	Georgia	A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, Georgian Low "about Traffic Movement" , The Georgian National StandardSST Gzebi:2009, SNIP 2.05.02-85
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	по ГОСТУ 13508-74 и ГОСТ 23457-86
	Thailand	Standard Drawings for Highway Construction, Department of Highways
	Viet Nam	Design standards
	Republic of Korea	보도설치및관리지침_Guidelines for pedestrian facility (MOLIT)
	Russian Federation	Interstate standard (GOST) 33151-2014 regulates all elements of traffic signs on motorways and general technical requirements and rules for their application.
	India	IRC:103-1998
	Philippines	In accordance to the Department Orders and Manuals
D-3. Pedestrian fences	Georgia	A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, Georgian Low "about Traffic Movement" , The Georgian National StandardSST Gzebi:2009, SNIP 2.05.02-85
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Thailand	Standard Drawings for Highway Construction, Department of Highways
	Viet Nam	QCVN:41
	Republic of Korea	보도설치및관리지침_Guidelines for pedestrian facility (MOLIT)

Row Labels	Country	Name
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD. This TSODD regulates the rules of application of traffic signs, traffic lights deployment, deployment of protective fences and deployment of signal devices
	India	IRC:103-1998
	Philippines	In accordance to the Department Orders and Manuals
D-4. Pedestrian refuge island	Bangladesh	In upcoming 4 lining of National Highway guideline has been proposed
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	по ГОСТУ 13508-74 и ГОСТ 23457-86
	Thailand	Standard Drawings for Highway Construction, Department of Highways
	Turkey	Rood Design Manual
	Viet Nam	QCVN:41
	Republic of Korea	보도설치및관리지침_Guidelines for pedestrian facility (MOLIT)
	Russian Federation	Interstate standard (GOST) 33151-2014 regulates all elements of traffic signs on motorways and general technical requirements and rules for their application.
	India	IRC-SP-41-1994
	Philippines	In accordance to the Department Orders and Manuals
E-1. Protected turn lane (pocket lane for turning)	Bangladesh	In upcoming 4 lining of National Highway guideline has been proposed
	China	Road Traffic Signs and Markings (GB5768-2009);Specification for Layout of Highway Traffic Signs and Markings (JTG D82-2009);Design Specification for Highway Alignment(JTG D20-2006)
	DPR Korea	Law on Road Construction and Road Designing Standard
	Georgia	A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, Georgian Low "about Traffic Movement" , The Georgian National StandardSST Gzebi:2009, SNIP 2.05.02-85
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	по ГОСТ10807-78 и ГОСТ 23457-86

Row Labels	Country	Name
	Thailand	Standard Drawings for Highway Construction, Department of Highways
	Turkey	Rood Design Manual
	Viet Nam	QCVN:41
	Republic of Korea	평면교차로설계지침_Guideline for level crossing facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD. This TSODD regulates the rules of application of traffic signs, traffic lights deployment, deployment of protective fences and deployment of signal devices
	India	IRC-SP-41-1994
	Philippines	In accordance to the Department Orders and Manuals
E-2. Intersection channelization	Bangladesh	In upcoming 4 lining of National Highway guideline has been proposed
	China	Road Traffic Signs and Markings (GB5768-2009);Specification for Layout of Highway Traffic Signs and Markings (JTG D82-2009);Design Specification for Highway Alignment(JTG D20-2007)
	Georgia	A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, Georgian Low "about Traffic Movement" , The Georgian National StandardSST Gzebi:2009, SNIP 2.05.02-85
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	по ГОСТ10807-78 и ГОСТ 23457-86
	Thailand	Standard Drawings for Highway Construction, Department of Highways
	Turkey	Rood Signs Manual 1-2
	Viet Nam	QCVN:41
	Republic of Korea	평면교차로설계지침_Guideline for level crossing facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD. This TSODD regulates the rules of application of traffic signs, traffic lights deployment, deployment of protective fences and deployment of signal devices
	India	IRC-SP-41-1994

Row Labels	Country	Name
	Philippines	In accordance to the Department Orders and Manuals
E-3. Roundabout	Bangladesh	Road Safety Works Manual-2005,
	Cambodia	MPWT, Standards Traffic Control Devices
	China	Specification for Layout of Highway Traffic Signs and Markings (JTG D82-2009)
	Georgia	A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, Georgian Low "about Traffic Movement" , The Georgian National StandardSST Gzebi:2009, SNIP 2.05.02-85
		A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, Georgian Low "about Traffic Movement" , The Georgian National StandardSST Gzebi:2009, SNIP 2.05.02-85
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	по ГОСТ10807-78 и ГОСТ 23457-86
	Turkey	Rood Design Manual
	Viet Nam	QCVN:41
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD. This TSODD regulates the rules of application of traffic signs, traffic lights deployment, deployment of protective fences and deployment of signal devices
	India	IRC-SP-41-1994
	Philippines	In accordance to the Department Orders and Manuals
F-1. Speed hump	Bangladesh	Road Safety Works Manual-2005
	China	Guide for Implementation of Improved Highway Safety to Cherish the Life Project (Tentative Standard);Guideline for Implementation of Highway Safety Enhancement Project
	Georgia	ГОСТ Р 552605-2006, Georgian Low "about Traffic Movement"
		ГОСТ Р 552605-2006, Georgian Low "about Traffic Movement"
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	СНиП 2.001-89 и Снип 2.05.02-85
	Viet Nam	QCVN:41

Row Labels	Country	Name
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 52605-2006 This TSODD regulate the use of "speed bumps" and their related, general technical requirements and rules for their application.
	India	IRC:99-1988
F-2. Visual traffic calming	China	Road Traffic Signs and Markings (GB5768-2009)
	Philippines	In accordance to the Department Orders and Manuals
F-3. Automatic regulation camera	China	General Specifications of Intelligent Monitoring and Recording System of Vehicles on Highways (GA/T 497-2009);Technical Specifications for Motor Vehicle Point-to-Point Speed Measurement (GA/T 959-2011)
	Georgia	EN 12966
	Tajikistan	Проект "Безопасный городв г. Душанбе"
	Viet Nam	Design standards
	Republic of Korea	교통단속처리지침_Guideline on traffic regulation and process (Korea national police agency)
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD This TSODD regulates the rules of application of traffic signs, traffic lights deployment, deployment travel of protective fences and deployment of signal devices and within it, there is a project of standards related to special technical devices which operate in automatic mode and consist of photo and video devices intended for controlling the movement of vehicles on the roads, and general technical requirements and rules for their application.
F-4. Variable speed limit	Cambodia	MPWT, Standards Traffic Control Devices
	China	Guidelines for Monitoring Technique of Motorway (No.3 Annoucement,2012)
	Georgia	EN 12966
	Tajikistan	по ГОСТ10807-78 и ГОСТ 23457-86
	Viet Nam	QCVN:41

Row Labels	Country	Name
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD. This TSODD regulates the rules of application of traffic signs, traffic lights deployment, deployment of protective fences and deployment of signal devices
	Philippines	In accordance to the Department Orders and Manuals
G-1. Bicycle lane	Thailand	Guide for Development of Bicycle Facility, Department of Highways
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD This TSODD regulates the rules of application of traffic signs, traffic lights deployment, deployment travel of protective fences and deployment of signal devices and within it, there is a project of standards related to special technical devices which operate in automatic mode and consist of photo and video devices intended for controlling the movement of vehicles on the roads, and general technical requirements and rules for their application. State standard (GOST) nr. R 52766-2007 regulates all elements of traffic signs on highways.
	India	IRC:11-1962
G-2. Exclusive motorcycle lane	Viet Nam	Design standards
G-3. Non-exclusive motorcycle lane	Cambodia	MPWT, Standards Traffic Control Devices
	Viet Nam	Design standards
	Philippines	In accordance to the Department Orders and Manuals
G-4. Motorcycle-friendly safety barriers	Viet Nam	Design standards
H-1. Reflection mirror	China	Guide for Implementation of Improved Highway Safety to Cherish the Life Project (Tentative Standard)
	Tajikistan	устанавливаются на опасных поворотах (нету национальных стандартов)
	Viet Nam	Design standards
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)

Row Labels	Country	Name
	Russian Federation	Interstate standard (GOST) 33151-2014 regulates all elements of traffic signs on motorways and general technical requirements and rules for their application.
H-2. Lighting	China	Specification for Highway Lighting (GB/T 24969-2010)
	Georgia	СНйП II-4-79, TEM STANDARDS AND RECOMMENDED PRACTICE
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	СН 278-64 и ВСН 22-75
	Viet Nam	Design standards
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	Interstate standard (GOST) 33151-2014 regulates all elements of traffic signs on motorways and general technical requirements and rules for their application. Interstate standards (GOST) 32753-2014 governs rules on highways related to the colored non-slip mats (i.e pedestrian crossings) and general technical requirements and rules for their application
	India	MoRTH Specifications for road & bridge works
	Philippines	In accordance to the Department Orders and Manuals
H-3. Variable message sign	China	Guidelines for Monitoring Technique of Motorway (No.3 Annoucement,2012)
	Georgia	EN 12966
	Tajikistan	по ГОСТ10807-78 и ГОСТ 23457-86
	Thailand	Exclusive Standards for Motorways, Department of Highways
	Viet Nam	Design standards
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 32865-2014 rules regulation of highways related to the use of light and informative signs and general technical requirements and rules for their application.
	India	IRC-SP-85-2010

Row Labels	Country	Name
	Philippines	In accordance to the Department Orders and Manuals
H-4. Roadside parking	DPR Korea	Law on Road Construction and Road Designing Standard
	Georgia	A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, Georgian Low "about Traffic Movement" , The Georgian National StandardSST Gzebi:2009, SNIP 2.05.02-85
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Thailand	Exclusive Standards for Motorways, Department of Highways
	Viet Nam	Design standards
	Russian Federation	Interstate standard (GOST) 33151-2014 regulates all elements of traffic signs on motorways and general technical requirements and rules for their application.
H-5. Emergency escape ramp	China	Guide for Implementation of Improved Highway Safety to Cherish the Life Project (Tentative Standard);Guideline for Implementation of Highway Safety Enhancement Project
	Thailand	Standard Drawings for Highway Construction, Department of Highways
	Turkey	Rood Design Manual
	Viet Nam	Design standards
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	Interstate standard (GOST) 33151-2014 regulates all elements of traffic signs on motorways and general technical requirements and rules for their application.
	Philippines	In accordance to the Department Orders and Manuals
H-6. Emergency telephones	China	Guidelines for Communication Technique of Motorway (No.3 Announcement,2012)
	Georgia	A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, Georgian Low "about Traffic Movement" , The Georgian National StandardSST Gzebi:2009, SNIP 2.05.02-85
		A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, Georgian Low "about Traffic Movement" ,

Row Labels	Country	Name
		The Georgian National StandardSST Gzebi:2009, SNIP 2.05.02-85
	Tajikistan	01, 02, 03 и 04
	Thailand	Exclusive Standards for Motorways, Department of Highways
	Viet Nam	Design standards
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 52766-2007 regulates all elements of traffic signs on highways.
	Philippines	In accordance to the Department Orders and Manuals
H-7. Sight distance	Bangladesh	Geometric Design Standards (Revised) Manual 2005
	Cambodia	MPWT, Standards Traffic Control Devices
	China	Design Specification for Highway Alignment (JTG D20-2006)
	DPR Korea	Law on Road Construction and Road Designing Standard
	Georgia	A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, ГОСТ Р 51256-99, Georgian Low "about Traffic Movement" ГОСТ 10807-78б ГОСТ 23457-86 ГОСТ Р 52 290—2004
		A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS 2001, ГОСТ Р 51256-99, Georgian Low "about Traffic Movement" ГОСТ 10807-78б ГОСТ 23457-86 ГОСТ Р 52 290—2004
	Sri Lanka	Gazette 444 -18 Published by Government of Sri Lanka (Based on Vienna convention on Road Traffic)
	Tajikistan	300м
	Turkey	Rood Design Manual
	Viet Nam	Design standards
	Republic of Korea	도로안전시설설치및관리지침_Guidelines on the installation and maintenance of a road safety facility (MOLIT)
	Russian Federation	State standard (GOST) nr. R 52289-2004 TSODD. This TSODD regulates the rules of application of traffic signs,

Row Labels	Country	Name
		traffic lights deployment, deployment of protective fences and deployment of signal devices
	India	IRC:86-1983, IRC:66-1976
	Philippines	In accordance to the Department Orders and Manuals

Part II

ASIAN HIGHWAY DESIGN STANDARDS FOR ROAD SAFETY

DRAFT ANNEX II BIS
INTERGOVERNMENTAL AGREEMENT ON THE ASIAN HIGHWAY NETWORK

Part III

ASIAN HIGHWAY DESIGN STANDARD FOR ROAD SAFETY

DESIGN GUIDELINES